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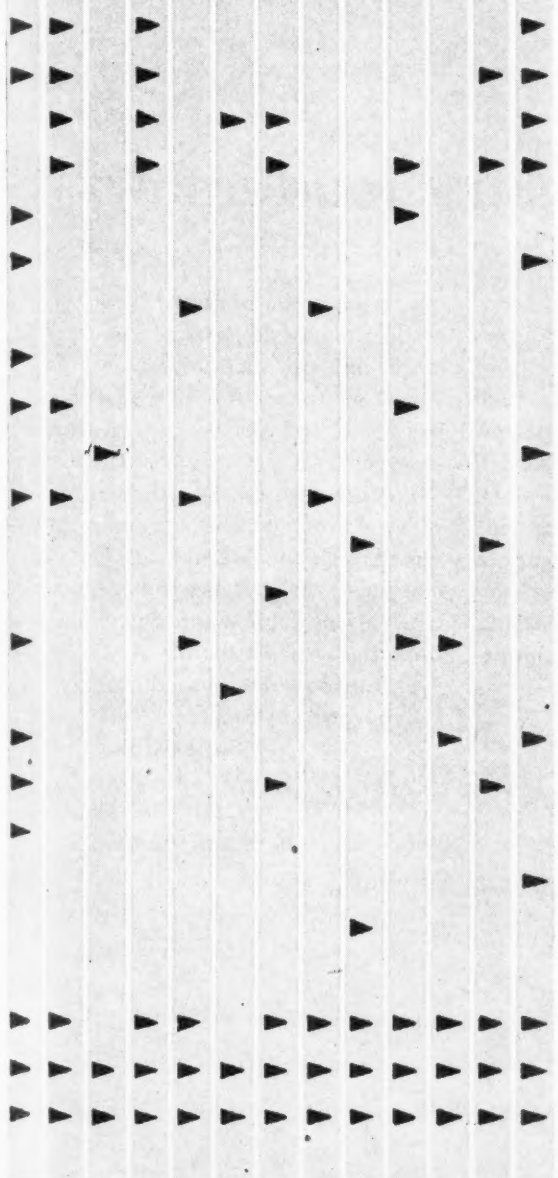

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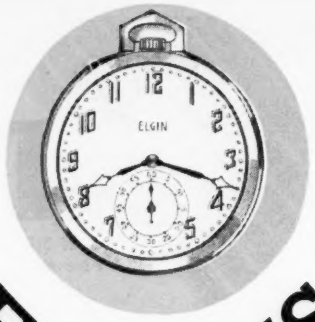

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POWER

A McGraw-Hill Publication—Established 1884

PHILIP W. SWAIN, *Editor*

DIESELS À LA CARTE

IT IS foolish to ask what type of prime mover is "best." The answer can never be the same twice in a row. What is meat for one plant will be poison for a dozen others.

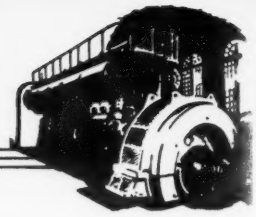
The job of the publication serving the broad needs of power engineers is to present a complete bill of fare and then lay down the principles that must guide the selection and combination of individual power units to suit individual needs.

From time to time the application of some particular prime mover will broaden rapidly. At such times questions will arise everywhere. Engineers of long experience will suddenly feel the need for new information. It's easy, then, to explain the steady stream of letters asking "What about the diesel engine? How will it fit my needs?" To answer them is not so easy. The editor cannot write a treatise on diesel engines for each of these inquirers. Nor can his off-hand comments replace the detailed appraisal of local requirements by a consulting engineer or by the analytically minded chief engineer on the spot.

The magazine can render its greatest service not by private correspondence, but by publishing foundation information for thousands of engineers. This is done regularly, month after month, in articles on diesel problems and installations. As an additional service, this number of *Power* assembles in a single place information most necessary to the power engineer who must stand prepared to fit the diesel engine into his own plant whenever he can profit.

We on *Power* have long seen a great future for the diesel, but not as the "best" prime mover, for there is no such thing. We feel now, more strongly than ever, that a position "for" or "against" the diesel, in competition with other types of prime movers, is simply not intelligent. In the long run the diesel will find its place —a very important place—in America's composite power plant. It will, we expect, dominate in certain applications. In others it will be unable to compete economically with steam. And, in an enormous number of places, now consistently overlooked by partisans, it will work with steam in double harness, for here, at least, two can often live cheaper than one.

Our advice to every power engineer, particularly every steam engineer, is this: Add diesel knowledge to your kit of mental tools. Be prepared to size up all power units that offer any possibilities of cutting costs and improving service. And then, in the light of all the facts, and without riding any old or new hobbies, make your engineering decisions on the basis of logic, experience and common sense.



LOOKING DIESELWARD

Why the diesel, and where? To provide some basis for an answer, E. J. Tangerman, associate editor, has prepared this article and those following

FIRST, what's a diesel? Sure, we all know in general, but specifically what is it? First it's an internal-combustion engine, which means that the furnace and prime mover are combined, the fuel being burned in the cylinder instead of outside as it is in a steam plant. In general the diesel looks and acts something like the engine in your automobile, but, with the exception of a few engine types in which a spark or hot surface is used in conjunction with compression to ignite the fuel, the diesel has no ignition system—which means no spark plugs, no coils, magneto or battery.

Further, instead of having a carburetor, which mixes air with the vaporized gasoline and then injects this mixture into the cylinder, the diesel just takes in air alone. It compresses this air to around 500 lb. per sq.in., then squirts in a little shot of fuel at very high pressure. This pressure and the shape of the nozzle work together to make a spray out of that shot of fuel oil. Meanwhile the air in the cylinder is whirling around, due to the speed with which it was drawn in, the shape and location of the passages by which it entered and the shape of the piston and cylinder head. This makes the oil spray mix fairly thoroughly with the air.

But remember that the air has been heated as it was compressed (if you don't believe it, grab the barrel of a bicycle pump while it's being pumped, or shut off the cooling water to an air compressor). The air has been raised from room temperature to about 1,000 deg. F.—hot enough so that any fuel will start burning in it.

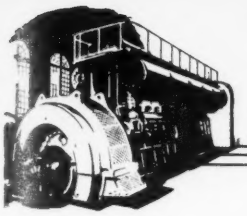
And that's just what happens. The fuel catches fire and burns within the cylinder, raising temperature, hence producing pressure against the piston head, pressure that does work. Depending upon combustion chamber shape and other factors, combustion usually starts somewhere near the center of the combustion chamber, because the air there is hotter due to lack of contact with the cold cylinder walls. As fuel is injected, some particles are either injected into this hot zone, or are carried there by the air current. There is a short delay while particles of oil absorb the heat and vaporize. As they vaporize, combustible parts of the fuel are in a hot gaseous state and in intimate contact with dense, hot air. Ignition follows promptly. Flames spread to adjacent particles. More fuel is steadily being injected. Some or much of it passes through the region where combustion is already under way; thus combustion spreads to all the fuel in the cylinder. The high-speed movies on pages 296-298 show what happens.

The hot gases create a high pressure which pushes against the piston just as steam would. This causes the power stroke. When the piston reaches the bottom of its stroke, the exhaust valve opens (or exhaust ports are exposed) and the burned gases pass out. The 4-stroke-cycle engine completes its cycle in four strokes of the piston, intake (down), compression (up), ignition and expansion (down) and exhaust (up). The 2-stroke-cycle engine uses only two strokes, since new air comes in under pressure to force out burned gases when the ports are uncovered by the piston. The new air is compressed in one stroke (up) and ignition and expansion occur on the other (down). Thus the 2-cycle engine requires a blower or a piston pump for scavenging air, but produces about 1.5 to 1.75 times the power for a given speed.

Combustion in modern diesels takes place partly at constant volume and partly at constant pressure. Because the fuel is burned in the cylinder where it does work, and because of the great temperature range of the cycle, you will get more work out of a given number of B.t.u.'s supplied to a diesel than you will out of an equivalent number supplied to any other thermal prime mover. Of course the diesel and the steam engine are both heat engines, in that they both convert heat units into mechanical work. There are two ways of explaining diesel economy and high efficiency. One is to compare diesel and gasoline engine. High compression means high efficiency. If a gasoline engine has too high compression it will have preignition. By contrast, the diesel must have high compression to work at all, hence is forced to be highly efficient to operate at all.

A Comparison

The second way is to compare diesel with steam or any other engine. In order to get high efficiency, heat must be put in at very high temperature, and since the diesel makes temperature higher due to its high compression, its efficiency will be higher. Instead of the 10% efficiency of the non-condensing steam engine plant or the 28% efficiency of high-class condensing central stations, the diesel will give you service out of 35 to 40% of the heat value in the fuel. The remaining two-thirds of the heat goes about 50-50 into exhaust and the cooling water circulated in the engine jacket. If you can use all of the hot water, and can use what heat you can get out of the exhaust gases, you may be able to get real use out of as much as 85% of



the heat in fuel (one German plant has actually gotten 91%). More about this particular problem later, because I know you are asking this question: "Well, if the diesel is so good, why don't I use diesels in my plant?"

That's getting right to the heart of the problem. The answer comes back to cost, over-all cost, not first costs or operating costs. Rather than enter a detailed discussion of certain typical cases, let us first set up a group of plant types in which diesels are real possibilities. Here they are:

1. Plants below 100-150 hp. Steam power plants in this range are very expensive and uneconomical under normal conditions, while diesel cost and economy are little influenced by engine size. In this range, the alternative is usually purchased power.

2. Plants from 150 up to 1,500 to 2,000 hp., that need little or no process steam. Here you might supply winter heating or small process heat demands from diesel waste heat.

3. Larger plants to 5,000 hp. or more which need little or no process steam. Local factors, character of load, etc., will govern the choice between steam and diesel in this range. Under normal conditions a steam plant may be more economical here.

4. Where process steam and electrical loads are out of phase. Here a combination steam diesel plant or a purchased-power-steam plant are the alternatives.

5. Where sudden load peaks are encountered or where load varies considerably. Great flexibility, low standby losses and quick-starting characteristics of the diesel may avoid banking or demand costs. Might be used in combination with purchased power on base load.

6. As standby or peak-load unit for steam or hydro plants or purchased power. The diesel advantage in the first two cases is quick-starting and no operating standby costs. With purchased power where a single feeder, long line or single-substation provides power, and supply must not be interrupted, diesel may be the answer. Competes in small sizes with gasoline engine.

7. As auxiliary drive in steam plant or hydro plant. Here the diesel should be properly installed to permit use of waste heat and thus work it into the plant heat balance. In this classification also come alternative drives for starting up or auxiliaries. Diesel competes here with gasoline engine in small sizes, but has better economy and no fire hazards.

8. Where the plant is isolated or fuel is hard to get or expensive, and where water supply is limited. It is usually cheaper to transport oil than other fuels, and the diesel requires much less cooling water.

9. In highly seasonal industries, i.e., milling, grinding, ginning, etc. With a very short season, a gasoline engine may prove better than the diesel; with very long seasons steam or purchased power may be better. On a very short season the cheapest possible prime mover is advisable because operating economy is not important. On a very long season, purchased-power demand charges and first cost of plant are less important and operating economy becomes all important.

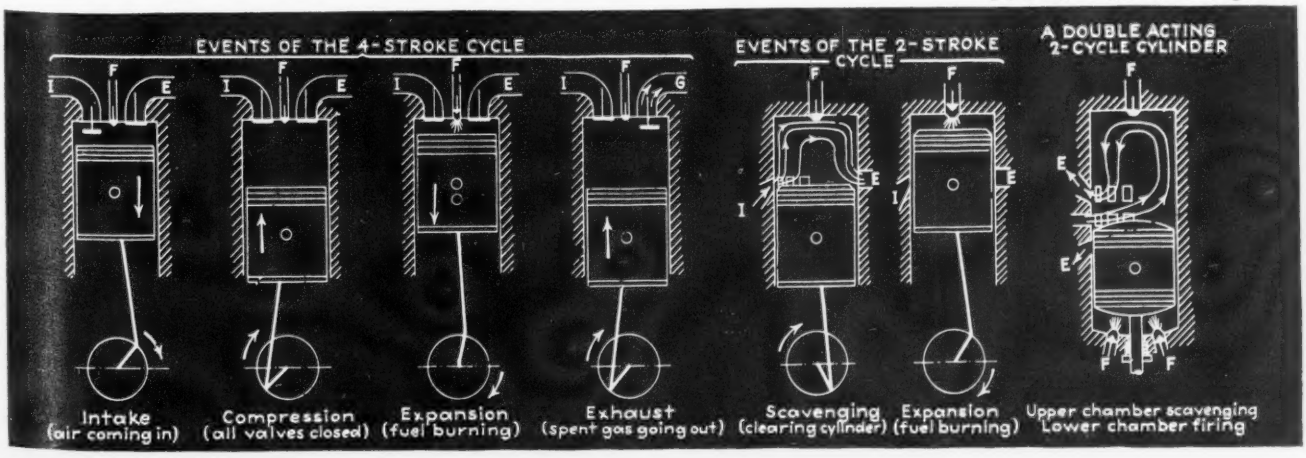
10. Plants with small and reasonably constant loads where occasional interruption is not vitally important, i.e., refrigeration, pumping, electroplating. This is an ideal type of load for almost any prime mover, and of course in case of fairly small load, ideal for the diesel. In very small installations, the diesel competes with purchased power; in larger ones with steam plants or purchased power.

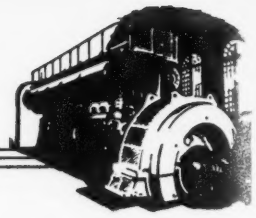
11. In plants where space is at a premium or in buildings without stacks, etc. In such cases it may be cheaper to install a diesel with its smaller space requirements than to utilize additional space for another type of plant.

12. For semi-portable plants. It is comparatively easy to run a diesel for construction work or similar semi-portable applications, while other types of prime movers are hard to install and remove.

13. For municipal or privately-owned central stations where no process steam is required and peaks are sudden and great. This is really a combination of Nos. 3 and 5, but is occasionally larger than the limit given in No. 3, for example, at the Vernon (Calif.) municipal plant.

14. As load-building plants for public utilities. Conditions here are usually like those listed in No. 5, with some of the characteristics of the installation of No. 12. Diesels may be added in increments as the load is built





up until a sufficient load is available to make installation of a transmission line economically feasible; then the diesels may be moved to another location.

15. As off-season, holiday, night or other special load condition. Engine might be semi-automatically controlled, possibly operated by watchman.

Of course, this list does not begin to cover all types of diesel installations in this country; it is intended merely to list the best possibilities for the diesel. Whether you operate a steam plant or a diesel plant you are probably buzzing with exceptions to this list. Of course, there are exceptions—many of them—based on such things as: relative prices of coal and oil; relative cost of steam plant, purchased power, hydro and diesel in a given location; amount and type of labor; load factors—even cost of water. The only proper approach to any problem of this nature is a detailed study of *your particular plant.*

Procedure

First lay out your plant—work out all the likely combinations—don't just work out an all-diesel plant against an all-steam or all-purchased-power set-up. Some of the possible arrangements are: straight steam, straight diesel, straight purchased power, steam for base loads with diesel for peaks and standby, purchased power with diesel for peaks, diesel for great proportion of summer load and steam for great proportion in winter (i.e. Singer Bldg. plant in this number), hydro with diesels for peak or standby, combination steam-diesel plant with some purchased power (i.e. Union Stock Yards Plant, Dec., 1932, *Power*). Of course all these won't apply to your particular plant. Some will be out before you start. Others may be possibilities.

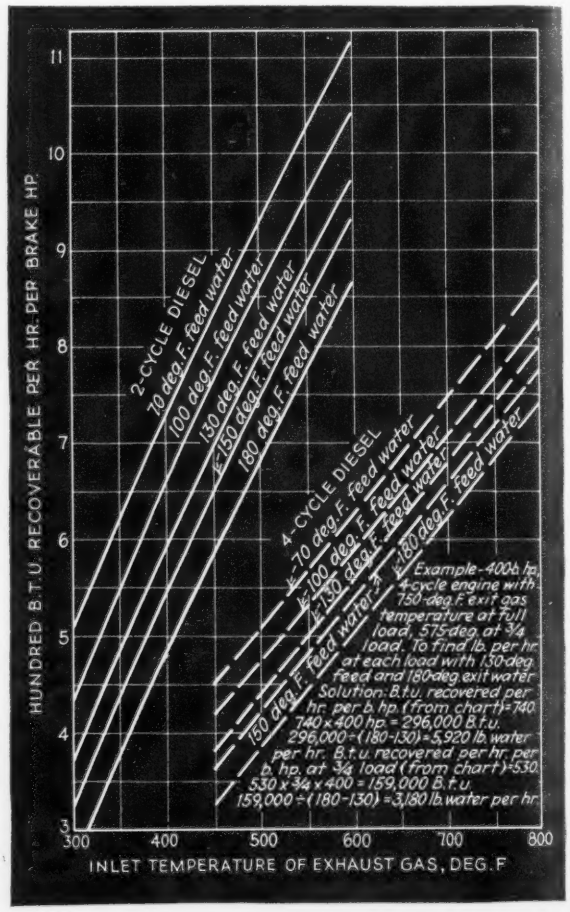
Lay out skeleton plants of these possible types and do a little preliminary figuring. To do this, get the cost of each plant and figure yearly fixed charges. Plot for each season a typical daily load curve for power and for process steam and/or building heat. Then get performance curves for your proposed units (boilers, steam prime movers, diesels, purchased power) at all loads. Now take your daily curves and figure hour by hour exactly what the complete plant will require in the way of these operating costs: Coal or oil, labor, repairs, supplies and miscellaneous, purchased power. Extend these figures to the whole season and combine the seasonal data to get the figures for a year. Allow for holiday, week-end, off-season and rush-season requirements. Then add fixed cost to yearly operating cost to get total yearly cost of producing *all* services by a combined plant.

Lowest *Combined* Cost

When these calculations have been made for each of the several types of plant, select the plant with the lowest *combined* cost.

Of course, initial or capital costs will vary considerably with the type of plant you want to put in, i.e., make of engine, design of building, type of foundation, character of sub-soil, kind of water supply available, and whether or not you make provision for use of waste heat.

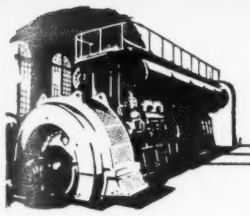
Here are some of the elements to be considered in your calculations, or those of your consultants: Fuel consumption per b.hp.-hr. for the diesel varies but


HUNDRED B.T.U. RECOVERABLE PER HR. PER BRAKE HP.
INLET TEMPERATURE OF EXHAUST GAS, DEG. F
2-CYCLE DIESEL
70 deg. F. feed water
100 deg. F. feed water
130 deg. F. feed water
150 deg. F. feed water
180 deg. F. feed water
4-CYCLE DIESEL
70 deg. F. feed water
100 deg. F. feed water
130 deg. F. feed water
150 deg. F. feed water
180 deg. F. feed water
Example—400 h.p. 4-cycle engine with 750-deg. F. exit gas temperature at full load, 575-deg. at ¾ load. To find lb. per hr. at each load with 130-deg. feed and 180-deg. exit water
Solution: B.t.u. recovered per hr. per b.hp. (from chart) = 740
740 × 400 hp. = 296,000 B.t.u.
296,000 ÷ (180-130) = 5,920 lb. water per hr.
B.t.u. recovered per hr. per b.hp. at ¾ load (from chart) = 530
530 × ¾ × 400 = 159,000 B.t.u.
159,000 ÷ (180-130) = 3,180 lb. water per hr.

Waste heat recoverable as hot water using a waste-heat boiler

little with size; in fact, varies much more with make of engine. Best fuel consumption so far obtained with a diesel is 0.33 lb. per b.hp.-hr., corresponding to an efficiency of about 41%. This was on a 5,500-hp. engine. Usual engines will average from about 0.40 to 0.45 lb. per b.hp.-hr. for small engines to 0.35 or 0.38 for large ones (full load at sea level. Down to half load, fuel consumption increases only slightly, but at quarter load and lower, consumption rises rapidly). Generally speaking, with equivalent design, there is less than 10% difference in fuel per b.hp.-hr. between engines of 100 and 1,000 hp., and hardly 20% difference between 50 hp. and 5,000 hp. Diesel lubrication is a function of rated b.hp. and hours of service, not of load.

In your analysis don't compare the diesel with the steam engine or turbine *alone*. Instead, compare the



complete plant incorporating a diesel (with or without other prime movers or boilers) with the *complete* plant not incorporating the diesel. Then select whichever has the lower combined cost for heat and power. It is important to remember that a diesel plant is usually put in and guaranteed as a unit by the engine manufacturer, while steam plants are assembled from several sources, hence no responsibility can generally be fixed if the plant fails to meet expectations.

Until recently, little waste heat was utilized by diesel plant operators. Of the 66%, roughly, of the total heat in the fuel which passes to the cooling water and exhaust gases, all the heat in the water and about half that in the exhaust is recoverable. In other words, only 15% need be lost. This 15% is lost as radiation and the marginal portion of exhaust heat not economical to recover for reasons of below-dewpoint corrosion and high cost of recovery apparatus. Further, it is not usually economical to attempt to recover waste heat from engines smaller than 100 hp.

This waste heat is available only at relatively low temperatures. Jacket water temperature averages around 120 deg. F. and may be anywhere from 100 to 150 deg. Exhaust gas temperature will run around 500 deg. F. on a 2-cycle, 650-700 deg. F., on a 4-cycle engine. This means that roughly 1 lb. of steam at 100 lb. pressure can be obtained per b.hp. per hr. Of course lower-pressure steam can be obtained in greater quantities (50% more steam at atmospheric pressure) and hot water or hot air (provided by jacketing the exhaust) in much greater amounts. For more expansive data on this problem, see the articles in *Power* late in 1933.

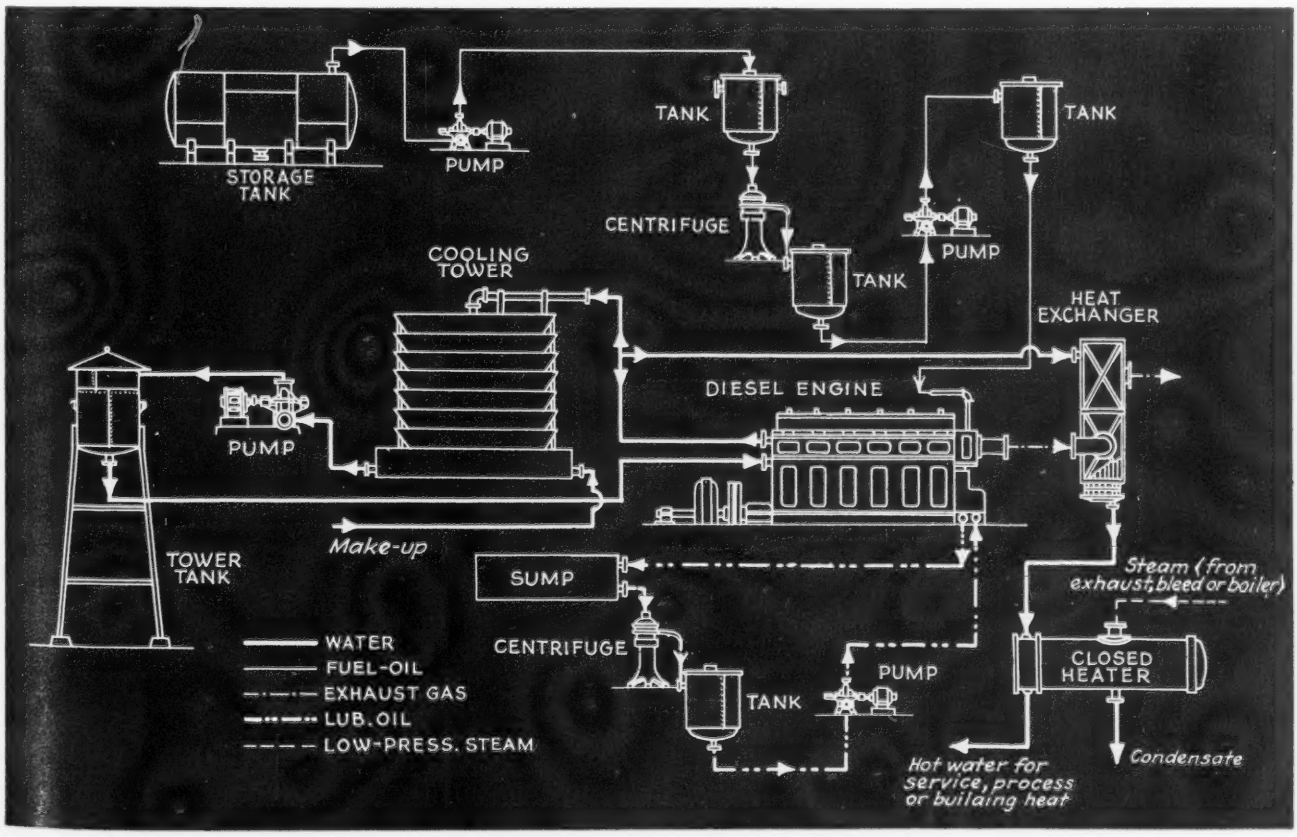
Rapid progress in development of automatically and semi-automatically controlled heating boilers, especially oil-fired, has opened possibilities for the diesel in buildings or plants where process steam or hot water is required. In an occasional plant a combination of diesel (with waste-heat recovery) with steam or hot-water heating boilers (sometimes burning diesel fuel), will show lower net costs than a byproduct steam plant.

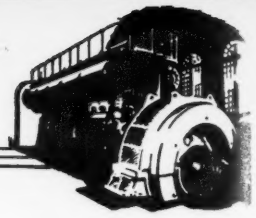
Depreciation of a diesel is not much different from that of a steam engine. Considering the plant as a whole, depreciation with the diesel may be slightly lower. One authority gives these maximums for the over-all investment in a slow-speed diesel plant: depreciation 5%, taxes and insurance 2%, cost of money 6%, or a total of 13%.

Auxiliaries may be as complex or as simple as desired. Diesels require less cubic content, floor space and foundation than steam plants, more than purchased-power switch and metering boards. Stack arrangements are simpler than for steam plants. Noise and vibration may be greater, but can be avoided by scientific isolation. Small diesels usually require addition of no more help, although competent, intelligent supervision and adequate cleaning will improve plant economy by reducing maintenance costs. Large diesel plants should have the same grade chief engineer as steam plants of similar size, but not as much other personnel.

Don't figure on operating a diesel at overloads—at

One type of diesel hook-up for use with a steam plant where low-grade oils are used and heat recovery is worthwhile





least not regularly or for appreciable periods. Even then don't figure on more than 5 to 10 per cent overload capacity.

As for fuel storage—diesels will require less space than the steam plant because of greater economy. Under normal conditions, diesel fuel is now readily available and need be bought only in quantities sufficient to get an economical price.

Trust the Builder

Design characteristics are no longer much of a problem for the diesel user. The manufacturer will decide what engine he thinks will best meet the specifications you set up, and since he is responsible for performance, should be allowed full latitude here. If you are not satisfied with a design and details as offered by some manufacturer, exclude that manufacturer from the bidding, for if you accept his general design you necessarily accept the details that go with it just as you would in purchasing an automobile or a suit of clothes.

Only by adopting this attitude can you buy at a reasonable price and only in that way can you hold the manufacturer strictly responsible for performance. This, of course, does not mean that you cannot make up tables for comparison of design details of the various engines offered. Such comparisons are legitimate provided they are made on a fair basis, but what is a fair basis of comparison? You can only make a fair comparison after careful analysis of reason for design and due allowances for all factors entering into the situation. This requires competent and skilled diesel consultants.

A few general remarks on design comparisons may not be amiss, however. 2-cycle and 4-cycle engines have always been rivals. Apparently the 2-cycle unit is generally preferred in bores above about 25 in., the 4-cycle in bores below about 8 in. Single-acting engines are almost always used, except in sizes above 5,000 hp., where double-acting units are usually built. Solid injection has almost replaced air injection in this country because of greater use of distillate fuels, greater simplicity and better specific consumption of light fuels. Air-injection engines now go in only where very poor fuels are burned or earlier engines are air-injection types. Likewise the vertical medium-speed engine has almost superseded the conventional slow-speed horizontal because of its higher speed, better balance, and more modern design characteristics.

Advances in diesel plant design and dependability of auxiliaries have also changed total plant costs. Instead of double the needed capacity in expensive (but very reliable) slow-speed engines, half for standby, the plant of today often has no standby whatever or at most a small cheap high-speed type. Since the diesel can be put "on the line" so quickly and is most economical at near full load, many modern plants use several small engines instead of one large, cutting them in and out as required by load conditions. This is favored by the fact that there is comparatively little difference in first cost per horsepower between large and small engines, and since smaller engines usually run faster, generators for them are cheaper. In addition to reduced operating cost and increased flexibility, such a plant is likely to have higher availability, in that when one engine goes off the line for any reason, a much smaller proportion of the plant is out of service.

First Cost of Plant

Now for the matter of first cost. Diesels smaller than 500 hp. usually cost much less per horsepower installed than do steam plants, and between 500 and 2,000 hp. about the same. Cost usually runs from $60 to $100 a horsepower, with the average around $75. (Cheap engines may run as low as $30 or $40). The higher figure would mean $100 a kilowatt, plus $25 or $30 a kilowatt for generator, exciter, foundation and installation. Cost will vary over quite a wide range, depending upon cooling-water installation, type of building, type of foundation, etc.

On a kilowatt-hour basis, fuel will cost 3.5 mills, lubricating oil 0.30 mill, and repairs and supplies about 0.5 mill, giving a total of 4.30 mills per kilowatt-hour with 4-cent (per gal.) fuel oil. With 5-cent fuel oil, the figure rises to 5.1 mills (At 3,000 kw.-hr. per yr. per kw. installed). This of course does not include labor, depreciation, interest on investment, insurance, building rent or other similar charges, nor does it credit the engine with the possible saving for recovery of waste heat. All these items vary so much with the particular plant that only very general figures may be given, some plants for example charging nothing for labor against the engine, because no more labor is required after the engine is installed than before. For reliable cost data on various sizes of plants, see the table on the pages 290-291. If you want more complete data, get a copy of the latest report of the Oil & Gas Power Division, American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y.

BIBLIOGRAPHY—In addition to the references in the preceding article, the following will prove of value in the solution of specific problems. All published since July, 1932, in POWER, they represent about ¾ of diesel material during this period and should still be available in your library. Complete lists of POWER articles on diesels are available in the annual index at your local library. For the history of the diesel, see p. 297, June, 34. Previous lists of installations appear in June, 33 and 34. Annual reports of design developments, etc., appear in Jan. each year, prospects for the future in Mid-Dec. (after A.S.M.E. meeting) and in June, 34. Meetings Oil & Gas Power Div., A.S.M.E., appear usually in July and Mid-Dec.

Operation and Maintenance: Depreciation, p. 156, Mar. 34; 64 diesels in one plant, p. 232, May 34; operating logs, p. 618, Nov. 34, maintenance log forms, p. 260, May 35; maintenance procedure, Apr. 35 and May 35, p. 667, Dec. 34; operating & maintaining, p. 522, Sep. 34; supercharging vs. additional engine, p. 634, Nov. 34; convertible gas-diesels, p. 70, Feb. 34; utility diesel operating costs, p. 563, Oct .34; lubrication costs, p. 516, Sept. 34; boiler fuel for diesels, p. 654, Dec. 33; British operating costs, p. 95, Feb. 33; waste heat, series of articles late 1933; fuel problems, p. 94, Feb. and p. 243, May 33; refrigeration plant, p. 273, May 33, Marshall, Minn., costs, p. 635, Dec. 33; Litchfield Minn., p. 144, Mar. 35; Rockville Center, p. 173, Apr. 33; testing lube oil, p. 122, Sep. 32; knocking, p. 315, Dec. 32.

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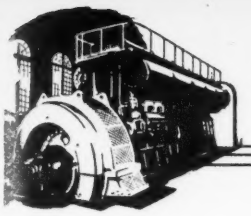


DIESEL MANUFACTURERS & SUPPLIERS

ALLIANCE MACHINE CO.
Alliance, Ohio
Engine under development

AEROL ENGINE CORP.
P.O. Box 875, Sayville, N. Y.
2-cy., S, V, up to 3,500 r.p.m.

AMERICAN DIESEL ENGINE CO.
Oakland, Calif.
4-cy., S, V, 25-200 hp., 200-2,000 r.p.m.

ANDERSON ENGINE & FOUNDRY CO.
Anderson, Ind.
2-cy., S, V, 20-420 hp., 257-400 r.p.m.

ATLAS-IMPERIAL DIESEL ENGINE CO.
Oakland, Calif.
2-cy., S, V, 10-200 hp., 300-700 r.p.m.
4-cy., S, V, 20-500 hp., 250-1,000 r.p.m.

BOLINDERS CO.
33 Rector St., New York, N. Y.
2-cy., S, V, 6-500 hp., 300-1,000 r.p.m.

BROMFIELD MFG. CO., INC.
211 Northern Ave., Boston, Mass.
2-cy., S, V, 12-150 hp., to 750 r.p.m.
4-cy., S, V, 5-200 hp., 200-2,000 r.p.m.
Deutz License

BRONANDER DIESEL ENGINE CO.
North Arlington, N. J.
S, V, opposed-piston, 10 hp., 750-1,500 r.p.m.

BUCKEYE MACHINE CO.
Lima, Ohio
4-cy., S, V, 40-600 hp., 514-400 r.p.m.

THE BUDA COMPANY
Harvey, Ill.
4-cy., S, V, 35-165 hp., 700-1,000 r.p.m.

BUSCH-SULZER BROS. DIESEL ENGINE CO.
2nd & Utah Sts., St. Louis, Mo.
2-cy., S & A, V, 700-10,000 hp., 80-600 r.p.m.
4-cy., S & A, V, 225-1,000 hp., 225-375 r.p.m.
A.E.G. License

CATERPILLAR TRACTOR CO.
Peoria, Ill.
4-cy., S, V, 47-130 hp., 820-900 r.p.m.

CHICAGO PNEUMATIC TOOL CO.
6 East 44th St., New York, N. Y.
4-cy., S, V, 80-800 hp., 257-400 r.p.m.

CLARK BROS. CO.
Olean, N. Y.
2-cy., S, H, 40-165 hp., 180-300 r.p.m.

CONSOLIDATED SHIPBUILDING CORP.
Morris Heights, N. Y. (Marine)
4-cy., S, V, 300 hp., 700 r.p.m.

CONTINENTAL GIN CO.
Birmingham, Ala.
2-cy., S, V, 50-180 hp., 250-300 r.p.m.

CONTINENTAL MOTORS
Detroit, Mich.
2-cy., S, R, 225-450 hp., 900 r.p.m.

COOPER-BESSEMER CORP.
Mt. Vernon, Ohio
4-cy., S, V, 15-1,500 hp., 240-1,200 r.p.m.

CUMMINS ENGINE CO.
Columbus, Ind.
4-cy., S, V, 40-500 hp., 600-1,800 r.p.m.

DeLaVERGNE ENGINE CO.
Paschall Station P.O., Philadelphia.
4-cy., S, V, 100-1,600 hp., 200-1,200 r.p.m.

DEUTZ MOTOR CORP.
2902 Woolworth Bldg., New York.
4-cy., S or A, V, 6-3,000 hp., 2,000-187 r.p.m.
4-cy., S or A, H, 4-1,400 hp., 1,500-187 r.p.m.
2-cy., S, V, 8-145 hp., 750-340 r.p.m.

ELECTRIC BOAT CO.
40 Wall St., New York, N. Y.
4-cy., S, V, 80-1,600 hp., 250-350 r.p.m. (Marine)

ENTERPRISE ENGINE CORP.
18th & Alabama Sts., San Francisco
4-cy., S, V, to 500 hp., to 650 r.p.m.

F.A.B. MANUFACTURING CO.
Oakland, Calif.
2-cy., S, V, 10-80 hp., 450-700 r.p.m.
Tuxham License

FAIRBANKS-MORSE & CO.
900 S. Wabash Ave., Chicago, Ill.
2-cy., S, V, 55-1,400 hp., 360-257 r.p.m.
4-cy., S, V, 10-160 hp., 1,200 r.p.m.

FRANKLIN VALVELESS ENGINE CO.
Franklin, Pa.
2-cy., H, low-compression

FULTON IRON WORKS CO.
St. Louis, Mo.
4-cy., S or A, V, up to 1,800 hp.

H. MILLS GARNER, INC.
30 Church St., New York, N. Y.
2-cy. "Petter," S, V, 7,400 hp., 650-280 r.p.m.
4-cy. "Ailsa Craig," S, V, 8-130 hp., 1,000-1,500 r.p.m.

GREENE MANUFACTURING CO.
Berkeley, Calif. (No data)

GUIBERSON DIESEL ENGINE CO.
Dallas, Texas (Airplane types)

HERCULES CO.
Canton, Ohio (Automotive types)

HILL-DIESEL ENGINE CO.
Lansing, Mich.
4-cy., S, or A, V, 7½-200 hp., 600-2,000 r.p.m.

F. VAN ROSSEN HOOGENDYK
Graybar Building, New York, N. Y.
Representing M. W. M., Mercedes-Benz, and Kromhout

HOOVEN, OWENS, RENTSCHLER CORP.
Hamilton, Ohio
2-cy., S or A, V, 1,200-12,000 hp., 120-250 r.p.m.
M.A.N. License

INGERSOLL-RAND CO.
11 Broadway, New York, N. Y.
4-cy., S, H or V, 50-1,500 hp., 600-257 r.p.m.

INTERNATIONAL HARVESTER CO.
Chicago, Ill. (No data)

AMERICAN M.A.N. CORP.
40 Rector St., New York, N. Y.
2-cy., S or A, V, 1,500-25,000 hp., 300-180 r.p.m.
4-cy., S or A, V, 40-2,000 hp., 1,000-200 r.p.m.

JOHNSON MANUFACTURING CO.
Seattle, Wash.
2-cy., S, V, 25-200 hp., 350-600 r.p.m.
4-cy., S, V, 35-105 hp., 500 r.p.m.

KAHLENBERG BROS. CO.
Two Rivers, Wis.
2-cy., S, V, 15-200 hp., 300-450 r.p.m.

LOMBARD GOVERNOR CO.
Ashland, Mass.
4-cy., A, V, 150-680 hp., 400-277 r.p.m.

MARKEY MACHINERY CO. INC.
Seattle, Wash.
2-cy., S, V, 12-32 hp., 425-450 r.p.m.

MASON DIESEL ENGINE CO.
3851-55 Santa Fe Ave., Los Angeles, Calif.
4-cy., S, V, 7½-75 hp., 950-1,750 r.p.m.

McINTOSH & SEYMOUR CORP.
Auburn, N. Y.
4-cy., S, V, 150-1,600 hp., 1,200-225 r.p.m.

MILLER IMPROVED ENGINE CO.
Springfield, Ohio
No data

MUNCIE OIL ENGINE CO.
Muncie, Ind.
2-cy., S, V, 45-360 hp., 300-257 r.p.m.
2-cy., S, H, 10-125 hp., 350-190 r.p.m.

MURPHY DIESEL CO., LTD.
S. 53rd & Burnham Sts., Milwaukee, Wis.
4-cy., S, V, 100-150 hp., 800-1,200 r.p.m.

MURRAY & TREGURTHA, INC.
North Quincy, Mass.
65-110 hp.

NATIONAL SUPERIOR CO.
Springfield, Ohio
2-cy., S, H, 30-120 hp., at 300 r.p.m.
4-cy., S, V, 50-800 hp., 275-700 r.p.m.

NORDBERG MANUFACTURING CO.
Chase & Oklahoma Sts., Milwaukee, Wis.
2-cy., S, V, 750-13,000 hp., 257-225 r.p.m.
4-cy., S, V, 150-1,000 hp., 400-327 r.p.m.
Fiat License

OIL CITY BOILER WORKS
Oil City, Pa.
No data

OTTO ENGINE WORKS
Holmesburg, Philadelphia, Pa.
4-cy., S, V, 25-100 hp., 1,600-1,200 r.p.m.

PAGE ENGINEERING CO.
Chicago, Ill.
4-cy., S, H, 60-240 hp., 400 r.p.m.

PEET & POWERS
70 E. 45th St., New York, N. Y.
4-cy., S, V, 3-38 hp., 500-1,200 r.p.m. (Lister)
4-cy., S, V, 32-600 hp., 1,000-430 r.p.m. (Ruston)
4-cy., S, H, 10-265 hp., 360-195 r.p.m. (Ruston)

PIONEER EQUIPMENT CORP. OF AMERICA (KRUPP)
Woolworth Bldg., New York, N. Y.
2-cy., S & A, V, 1,230-10,100 hp., 97-200 r.p.m.
4-cy., S & A, V, 58-2,500 hp., 200-900 r.p.m.

POWER MANUFACTURING CO.
Marion, Ohio
2-cy., S, V & H, to 185 hp., 327 r.p.m.

RATHBUN-JONES ENGINEERING CO.
Toledo, Ohio
4-cy., S, V, 200-1,500 hp., 360-240 r.p.m.

RED WING MOTOR CO.
Red Wing, Minn.
4-cy., S, V, 100-140 hp., 1,800 r.p.m.
Waukesha Motor Co. License

JOSEPH REID GAS ENGINE CO.
Oil City, Pa.
2-cy., S, H, 25-150 hp., 190-400 r.p.m.

STACEY INTERNATIONAL CORP.
Beaumont, Texas
No data

STANDARD MOTOR CONSTRUCTION CO.
180 Whiton Street, Jersey City, N. J.
4-cy., S, V, 45-440 hp., 650-277 r.p.m.

FRANK BALLOU STEARNS
Hanna Bldg., Cleveland, Ohio
"Diamond" diesel

STERLING ENGINE CO.
Buffalo, N. Y.
2-cy., H, "crankless" diesel

STOVER MFG. & ENGINE CO.
Freeport, Ill.
4-cy., S, V, to 10 hp., 1,000 r.p.m.

STRAUB MANUFACTURING CO.
Oakland, Calif.
No data

SULZER BROS. LTD.
50 Church St., New York, N. Y.
U. S. Representative—D. Dasso

SUN SHIPBUILDING & DRY DOCK CO.
Chester, Pa.
2-cy., opposed-piston, S, Doxford & Junkers
Setz double-acting engines

TIPS ENGINE WORKS
Austin, Texas
No data

TITUSVILLE IRON WORKS, TITUSVILLE, PA.
2-cy., H, low-compression

UNION DIESEL ENGINE CO.
Oakland, Calif.
4-cy., S, V, 34-800 hp., 235-600 r.p.m.

UNION MACHINE CO.
San Francisco, Calif.
2-cy., S, V, 65-270 hp., 375 r.p.m.

VENN SEVERIN MACHINE CO.
Chicago, Ill.
2-cy., S, V, 30-300 hp., 277-400 r.p.m.

WASHINGTON IRON WORKS
Seattle, Wash.
4-cy., S, V, 45-1,000 hp., 450-200 r.p.m.

WAUKESHA MOTOR CO.
Waukesha, Wis.
4-cy., S, V, 20-300 hp., 850-2,600 r.p.m.
Comet and Hesselman Licenses

WEBER ENGINE CO.
Kansas City, Mo.
2-cy., S, H, 25-80 hp., 200-300 r.p.m.

WESTERN ENTERPRISE ENGINE CO.
Los Angeles, Calif.
4-cy., S, V, 280-800 hp., 900 r.p.m.
Beardmore 2-cy. license

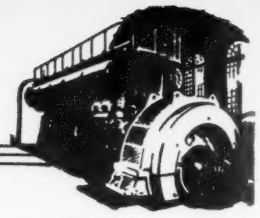
WINTON ENGINE CORP.
2160 W. 106th St., Cleveland, Ohio
4-cy., S, V, 15-1,500 hp., 1,600-225 r.p.m.

WITTE ENGINE WORKS
1664 Oakland Ave., Kansas City, Mo.
4-cy., S, H, 5-10 hp., 850-720 r.p.m.

WOLVERINE MOTOR WORKS, INC.
Bridgeport, Conn.
2-cy., S, V, 25-95 hp., 425-500 r.p.m.
4-cy., S, V, 50-200 hp., 350-400 r.p.m.

WORTHINGTON PUMP & MACHINERY CORP.
Harrison, N. J.
2-cy., S, H, to 75 hp., to 300 r.p.m.
4-cy., S, V, 25-1,500 hp., 514-225 r.p.m.

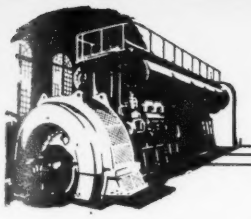
Listings are as complete and accurate as available information permits, but Power assumes no responsibility for errors or omissions. Almost all listings supplied by manufacturers. Abbreviations are: cy.—cycle, S—solid injection, A—air injection, V—vertical, H—horizontal, R—radial. Speeds listed are normally as follows: highest speed for lowest-power engine, and vice versa. Where speed range is small, it usually indicates speed range on any given size engine.



OPERATING COSTS OF

Data condensed from the latest Report on Oil Engine

Character of Plant (See Notes)	Type of Load (See Notes)	Number of Engines	Total Installed B.H.P.	Total Plant Hours Operated in Reported Period	Total Gross Output—K.W. Hrs.	Total Net Output—K.W. Hrs.	Percent of Gross K.W. Hrs. for Plant Purposes	Annual Plant Load Factor (See Notes)	Running Plant Capacity Factor (See Notes)	Plant Service Factor (See Notes)	Average Cost of Fuel Oil—Cents per Gallon	Average Cost of Lubricating Oil—Cents per Gallon	Costs per Net K.W. Hr.—Mills						
													Fuel Oil Cost	Lubricating Oil Cost	Attendance Cost Including Superintendence	Cost of Supplies and Misc., including Water	Cost of Engine Repairs	Cost of All Other Plant Repairs	Combined Cost of All Repairs, Supplies and Miscellaneous	Total Production Cost
U	C	9	15,640	8,760	30,795,736	27,434,541	10.9	55.1	74.3	45.1	3.39	28.8	2.88	0.23	0.77	0.09	0.75	0.23	1.07	4.95
M-W	C	7	8,960	8,760	9,995,550	9,014,095	9.8	34.0	63.2	30.0	4.24	58.5	3.94	0.47	2.74*a*	0.87	1.37*a*	1.45*a*	3.69	10 84
M	C	5	7,445	8,760	9,949,800	9,530,892	4.2	37.6	78.3	29.0	4 26	58.6	3.75	0.24	2.43	0.21	0 48	0 09	0.78	7.20
M-W	C	4	5,000	8,760	8,921,600	8,379,100	6.1	44.3	67.2	45.1	1.60	56.0	1.69	0.32	2.03	0.08	0.33	0.02	0.43	4.47
M	C	5	4,250	8,760	4,984,325	4,471,550	10.3	35.6	56.9	35.1	3.10	37.2	3.30	0.16	2.56	0.07	0.39	0.15	0.61	6.63
M	C	4	3,675	8,760	5,135,900	4,543,778	11.5	39.1	63.2	37.6	3.45	49.8	3 29	0.41	3.27	0.44	0.25	0.35	1.04	8.01
M	C	4	3,600	8,760	5,238,400	4,919,360	6.1	43.7	67.8	36.5	4.27	61.4	4 27	0.69	1.50	0.43	0.37	0.10	0 90	7.36
U	V-T	2	3,520	5,840	2,162,100	2,122,944	1.8	10.7	83.6	12.5	4.48	52.6	4 07	0.31	1.56	0.32	0.32	0 02	0.66	6 60
M-W	B&P-T	3	3,450	2,266	5,071,720	4,980,440	1.8	24.6	97.3	25.7	1 92	21.5	1 77	0.15	1.82	0.11	0.36	0 04	0.51	4.24
I	B-Z	4	3,360	8,760	13,784,200	13,289,000	3.6	....	87.0	80.1	4.01	22.5	3.15	0.29	1.32	0.24	1.80	0.60	2.64	7.41
U	C-Z*b*	1	3,000	8,760	5,790,900	4,511,158	22.1	38.9	39.3	83.5	4 91	38.9	4.67	0.48	1.87	0.35	0.83	0.01	1.19	8.21
M	S-H	3	2,925	8,760	959,960	931,425	2.9	9.5	47.9	11.7	5.95	81.8	7.51	0.73	6.85	0.90	0.80	0.10	1.80	16.89
M	C	5	2,730	8,760	3,359,900	3,114,320	7.3	41.6	57.5	36.4	3 80	30.0	3 48	0.27	3.04	0.35	0.72	0 58	1.65	8.44
U	P-T	5	2,520	8,760	1,222,560	988,290	19.2	10.0	52.0	15.8	2 62	45.0	3.99	1.25	8.32	1.55	2.82	0.35	4.72	18 28
U	S-	3	2,520	.....	184,300	142,039	22.9	1.9	....	....	3 97	49.6	4.00	0.47	18.09	4.04	5.74		9.78	32.34
M	P-H	2	2,500	2,264	1,677,900	1,639,420	2.3	10.4	99.2	11.5	5 28	44.0	5.03	0.38	1.74	0 84	0.70	0	1.54	8 69
I	C	3	2,400	8,760	939,700	777,920	17.2	20.6	21.6	30.8	5.16	55.1	9.83	1.52	11.34	0.25	0.96		1.21	23.90
U	S-	2	2,400	.....	290,760	262,329	9.7	2.0	....	....	3.90	55.0	3.68	0.21	11.44	2.00	0.81		2.81	18.14
M-W	C	3	2,370	8,760	3,329,790	3,279,790	1.5	31.7	59.7	40.0	4.37	46.1	4.45	0.66	4.44	0.39	0.17	0.39	0.95	10 50
U	S-T	4	2,370	2,242	1,411,510	1,349,830	4.4	10.2	73.8	13.7	4.41	49.7	4.24	0.53	4.59	0.72	1.11	0 28	2.11	11.47
M-W	C-Z*b*	3	2,250	8,760	3,149,100	3,101,023	1.5	44.9	60.2	39.5	4.31	26.7	3.95	0.30	2.15	0.13	1.14		1.27	7.67
M	C	5	2,170	8,760	3,230,400	3,065,966	5.1	41.0	64.8	39.1	3.23	39.9	2.88	0.52	3.12	0.43	0.39	0	0.82	7 34
U	S-	3	1,160	.....	918,180	834,039	9.2	7.0	....	....	4.02	47.6	4.59	0.54	3.65	0.45	0.65		1.10	9 89
M	C	4	2,100	.....	1,652,500	1,616,773	2.2	12.7	93.5	14.3	4.34	50.2	3.79	0.43	1.67	0.32	0.83		1.15	7 04
M-W	C	4	2,060	8,760	3,516,800	3,347,210	4.8	59.9	65.4	44.4	3.73	46.2	4.02	0.50	1.29	0.13	0.46	0 04	0.63	6 44
I	B-Z	2	2,000	3,561	3,224,550	3,216,935	0.3	26.8	81.6	33.6	4 81	37.9	4.05	0.34	1.49	0.07*c*	0 37	0	0 44	6 32
U	B-T	3	2,000	8,760	3,981,520	3,814,300	4.2	49.9	69.9	48.4	2 10	66.6	2.01	0.68	2.24	1 00	0 22	0.81	2 03	6 95
I	C	3	1,980	1,800	926,340	886,688	4.3	....	57.6	17.6	4 75	67.4	4.27	0 74	6.39	0.27	0	0	0.27	11 67
U	S-H&T	2	1,960	8,760	1,194,900	1,163,860	2.6	11.4	78.9	13.1	4 49	50.7	4 02	0.32	1 44	0.55	0.46	0	1 01	6 79
U	P-T	4	1,885	8,760	1,416,913	1,223,713	13.6	32.3	47.5	26.9	3 56	80.5	3 90	0.86	5 06	0.88	0	0 44	1.32	11.15
M-W	C	3	1,875	8,760	2,548,000	2,440,000	4.3	36 9	54 9	42.1	2 31	52 0	2.18	0 51	2.94	0 61	0 23	0.10	0 94	6 57
U	C	5	1,875	8,760	2,064,771	1,920,591	7.0	39.3	47 1	39.8	2 51	40.4	3 57	0 90	6 01	0 51	5 15	0.98	6 64	17 12
U	P&S-T	4	1,865	.....	206,550	186,791	9.5	2 8	64 1	2 9	4 17	30 2	5 31	0 80	21 35	3 76	3 17	3 87	10 80	38 26
M-W	B-G	2	1,800	8,760	3,802,600	3,689,473	3.0	....	63 1	....	2 32	53 0	2.02	0 47	2 85	0 16	0 07	0	0 23	5 57
U	C	3	1,770	8,760	1,489,775	1,434,575	3.7	36 2	47 3	30 2	3 93	38 6	4 57	0 74	2 97	0 44	1 26	0	1 70	9 98
U	B-T	3	1,770	8,760	2,177,480	2,064,467	5.2	28 3	55 8	37 5	3 98	36 5	3 87	0 24	1.76*c*	0 32	0 15	0 09	0 56	6 43
U	P&S-T	1	1,760	2,920	343,172	317,690	7.5	3 9	55 4	6 0	6 06	59 3	7 24	0 56	5 35	4 90	0 07*f*	0 39	5 36	18 51
W	S-T	2	1,750	8,760	337,200	336,189	0 3	6 8	70 8	4 6	3 60	49 0	3 27	0 29	2 17	0 30	2 07	0	2 37	8 10
U	S-T	4	1,705	8,760	774,780	709,180	8 5	8 0	84 9	9 1	4 53	77 2	4 36	0 56	7 98	1 25	1 26	0 32	2 83	15 73
U	S-Z	2	1,680	8,760	7,870	6,585	16 3	0 2	48 1	0 2	2 76	....	4 00	0	182 48	2 64	0	1 36	4 00	190 47
U	C	3	1,650	.....	2,205,070	2,112,805	4.1	26 8	60 4	37 6	4 22	49 9	4 16	0 50	1 74	0 31	0 72		1 03	7 44
M-W	C	4	1,620	8,760	2,532,910	2,470,900	2.5	42 8	57 9	45 9	3 04	52 1	3 18	0 48	2 84	0 36	0 10	0	0 46	6 96
M-W	C	3	1,560	8,760	1,554,430	1,511,411	2 8	....	51 6	32 8	3 44	40 0	3 64	0 43	4 84	0 26	1 07	0 08	1 41	10 32
M	C	4	1,560	8,760	1,589,240	1,482,043	6.8	42 7	50 0	34 6	3 51	58 4	4 48	0 83	3 05	0 71	0 24	0 28	1 23	9 59
W	C	2	1,500	6,199	2,080,220	2,057,220	1.1	54 0	66 6	35 4	1 82	21 0	1 68	0 25	3 72*g*	0 47	0 74	1 07	2 28	7 92
U	C-T	1	1,500	8,760	3,021,340	2,967,310	1.8	32 9	65 9	52 0	6 01	45 1	5 15	0 28	1 18	0 49	0 26	0	0 75	7 36
M	C	2	1,500	8,760	2,455,900	2,433,000	0 9	37 4	54 3	51 2	5 51	71 3	5 47	0 22	6 16	0 23	0 12	0 05	0 40	12 25
M	C	4	1,465	8,760	2,747,030	2,625,010	4 5	38 3	71 0	44 9	4 30	52 0	3 83	0 62	4 29	0 33	0 54	0 26	1 13	9 87
M	C	3	1,450	8,760	1,201,175	1,108,150	7 7	21 1	44 4	31 7	4 08	64 8	4 39	0 37	4 98	0 89	0 44	0	1 33	11 07
U	B-T	2	1,440	8,760	2,844,460	2,736,620	3 8	33 2	56 9	59 0	4 69	39 0	4 81	0 46	1 83	0 30	0 61	0 01	0 92	8 02
M-W	C	3	1,420	8,760	1,791,883	1,594,598	11 0	41 7	52 0	41 2	3 16	45 0	3 92	0 61	3 20	0 24	0 08	1 21	1 53	9 26
U	P-T&Z	2	1,410	8,760	2,516,180	2,463,870	2 1	30 3	73 2	41 5	5 01	35 2	4 94	0 38	1 98	0 12	0 64	0	0 76	8 06
U	C	3	1,400	.....	1,513,170	1,483,854	1 9	30 3	79 2	23 2	3 87	52 8	3 18	0 33	2 81	0 31	1 48		1 79	8 11
I		3	1,400	8,760	1,771,725	1,636,205	7 7	20 2	55 0	39 1	3 44	26 3	3 58	0 17	1 24	0 74	2 07		2 81	7 80
U	P-T	1	1,400	5,976	3,666,420	3,514,032	4 2	41 9	70 6	63 1	3 52	15 3	3 26	0 11	0 77	0 11	0 42		0 53	4 67
M	C	2	1,375	8,760	1,122,560	1,034,979	7 8	34 2	27 7	50 1	3 65	60 6	4 51	0 76	4 19	0 30	0 07	0 01	0 38	9 84
U	C	3	1,375	8,760	2,326,490	2,252,600	3 2	31 6	52 1	55 2	4 69	51 9	4 76	0 32	5 45	2 02	2 52	0 68	5 22	15 75
U	B-T	4	1,310	8,760	2,071,200	2,013,550	2 8	37 5	57 8	46 5	3 59	55 1	3 38	0 80	2 19	0 32	0 04	0 02	0 38	6 75
U	C	4	1,305	8,760	913,325	865,747	5 2	34 0	40 7	29 3	4 74	50 6	7 00	1 26	5 88	1 71	2 76	0 13	4 60	18 74
M-W	C	3	1,225	8,760	1,300,700	1,153,244	11 3	39 6	56 4	32 0	4 72	41 9	5 55	0 86	3 35	0 70	0 37	0 38	1 45	11 21
U	B-T	3	1,200	282	113,136	109,596	3 2	1 6	93 3	1 7	3 23	50 0	3 13	1 35	11 95	6 25	8 83	2 89	17 97	34 40
U	C	2	1,200	.....	1,997,800	1,946,839	2 6	28 2	59 2	47 8	4 23	50 5	4 19	0 38	1 69	0 43	0 81		1 24	7 50
U	P-T	2	1,200	8,760	1,668,900	1,599,147	4 1	25 1	61 8	38 2	4 09	39 8	4 10	0 45	2 67*c*	0 31	0 34	0 01	0 66	7 88
U	C-T	1	1,200	8,760	2,461,720	2,365,854	3 9	36 5	68 5	50 9	5 20	36 6	4 89	0 20	1 06	0 18	0 62	0	0 80	6 95
M	C	2	1,200	8,760	1,757,700	1,724,300	1 9	39 4	51 0	48 8	4 35	43 3	4 26	0 43	6 79	0 15	0 19	0 04	0 38	11 86
U	B-T&Z	1	1,200	.....	2,695,050	2,652,550	1 6	38 5	73 5	51 9	4 00	47 3	3 04	0 34	1 18	0 25	0 43	0 01	0 69	5 25
M	C	4	1,165	8,760	944,470	876,218	7 2	30 8	37 1	37 2	5 55	53 1	7 75	1 66	6 28	0 62	0 84	0	1 46	17 15
U	-T	3	1,160	8,760	2,258,880	1,860,122	17 7	36 8	75 3	44 0	3 24	50 4	3 89	0 60	1 80	0 53	0 69	0 54	1 75	8 04
M	C	3	1,150	8,760	1,581,800	1,430,450	9 6	36 1	59 0	39 6	4 40	52 9	4 20	0 59	4 75	0 45	0 73	0 23	1 41	10 96
U	C	3	1,140	8,760	1,162,920	1,086,909	6 5	39 1	36 0	48 2	4 53	47 5	5 82	0 48	5 46	1 52	0 06	0 04	1 62	13 38
I	C	2	1,060	8,760	2,335,124	2,239,317	4 1	31 9	54 2	69 1	5 06	48 1	5 48	0 38	3 53	0 20	0 67	0 16	1 03	10 42
M-W	C	3	1,060	8,760	1,668,238	1,563,450	6 2	48 8	57 9	46 2	3 40	42 4	3 62	0 45	2 40	0 17	2 57	0 13	2 87	9 34
M	C	2	1,050	8,760	1,586,400	1,460,200	8 0	40 3	51 1	50 4	4 16	51 3	4 49	0 90	4 11	0 17	0 02	0	0 19	9 69
M-W	C	3	1,050	8,760	810,365	734,445	9 3	44 1	52 8	24 9	5 18	57 2	5 84	0 78	7 03	0 47	0 57	0 05	0 99	14 64
U	B-T	1	1,050	8,760	2,815,400	2,745,800	2 5	45 9	63 4	71 9	4 28	38 2	3 86	0 24	1 63	0 27	0 39	0 03	0 69	6 42
M-W	C	3	1,050	8,760	1,730,300	1,648,088	4 7	38 3	62 9	44 6	4 83	49 9	4 29	0 79	2 17				1 10	8 35
I	C	2	1,000	2,880	1,351,199	1,251,011	7 4	19 3	70 3	32 7	4 96	45 0	4 43	0 35	3 27	0 30	0 14		0 44	8 49
JU	B-Z	1	1,000	8,760	4,428,200	4,206,500	5 0	72 2	90 0	83 7	3 99	61 8	3 48	0 32	0 88	0 20	0 57	0 09	0 86	5 54
U	B-Z&T	1	980	.....	2,256,400	2,155,929	4 4	36 8	83 5	46 9	3 46	26 4	3 16	0 24	0 76	0 16	1 32		1 48	5 64
U	B-T	3	900	8,760	1,368,900	1,314,144	4 0	31 2	66 7	38 8	2 49	63 6	2 36	0 68	4 06	0 48	1 91	0 01	2 40	9 50
U	B-T	1	900	5,256	1,635,670	1,510,370	7 7		79 9	64 4	3 81	47 0	3 31	0 40	1 96	0 27	0 23	0 12	0 62	6 29
M	S&P-H	1	900	.....	180,000	156,190	13 2	3 6	48 3	7 0	3 95	60 0	4 92	0 89	2 56	0	0 35		0 35	8 72
M-W	C	3	900	8,760	709,290	670,266	5 5	25 3	39 0	34 3	2 98	55 0	4 15	0 74	6 74	0 45	0 71	0	1 16	12 79
U	P-T	2	900	8,760	1,880,400	1,777,476	5 4	41 3	63 5	56 0	5 19	41 6	6 07	1 04	2 42	0 20	1 51	0 05	1 76	11 29
U	B-T	1	900	420	221,120	209,620	5 2	4 6	87 0	4 8	4.13	50 2	3 22	0 61	2 69	2 54	2 26	2 54	7 34	13 86



156 DIESEL PLANTS

Power Cost of the A.S.M.E. Oil and Gas Power Division

Character of Plant (See Notes)	Type of Load (See Notes)	Number of Engines	Total Installed B.H.P.	Total Plant Hours Operated in Reported Period	Total Gross Output—K.W. Hrs.	Total Net Output—K.W. Hrs.	Percent of Gross K.W. Hrs. for Plant Purposes	Annual Plant Load Factor (See Notes)	Running Plant Capacity Factor (See Notes)	Plant Service Factor (See Notes)	Average Cost of Fuel Oil—Cents per Gallon	Average Cost of Lubricating Oil—Cents per Gallon	Costs per net K.W. Hr.—Mills: Fuel Oil Cost	Lubricating Oil Cost	Attendance Cost Including Superintendence	Cost of Supplies and Misc., including Water	Cost of Engine Repairs	Cost of All Other Plant Repairs	Combined Cost of All Repairs, Supplies and Miscellaneous	Total Production Cost
M	C	3	850	8,760	1,010,820	956,138	5.4	38.5	32.8	61.6	3 61	75 6	4 57	0 70	6 24	0 34	0.21		0 55	12 06
U	S-	1	840	.	81,080	60,200	25 7	1 7	...	...	4 00	66 7	4 70	1 66	25 76	6 48	11.43		17 91	50 03
U	B-T	1	840	.	376,760	369,381	2.0	7 8	78 4	9 7	4 20	50 2	3 69	0 46	2 22	0 71	0 79	1 28	2 78	9 15
U	B-T	1	840	. . .	402,770	390,760	3 C	8 2	82 3	9 9	4 28	50 1	3 34	0 66	2 59	1 01	0 52	0 28	1 81	8 40
U	P-T	1	840	....	1,266,600	1,145,142	9.6	30.7	49 8	51.4	3.90	39 2	5.12	0.23	3 22[e]	0 44	1 46	0 05	1 95	10 52
U	P-Z&T	1	840	.....	425,890	379,021	11 0	8.1	62.3	13 8	3.50	21 2	3.65	0 29	4 96	2 10	3 76		5 86	14 76
U	P-T	1	825	8,760	478,260	462,470	3.3	9 1	68 0	14 5	5 29	48 0	5 05	1 70	8 59	1 31	0 52	1 05	2 88	18 22
U	S-T	3	810	2,920	100,000	87,586	12.4	2.1	77 4	2 7	4 36	49 1	5 82	1 27	24 48	4 95	1 70	0 94	7 59	39 16
U	B-T	2	800	5,000	1,125,370	1,095,200	2.7	32.1	67 6	35.4	3.90	46 0	3 64	0 43	2 84	0 28	0 16	0 05	0 49	7 40
M-W	C	3	740	8,750	1,193,300	1,104,807	7.5	34.1	63 1	43.4	3.78	45.1	3.94	0 69	5 28	0 25	0 31	0 05	0 61	10 52
M	C	3	725	8,760	619,650	531,546	14.2	27.2	46.4	31.4	4.90	50 2	5 81	0 31	6 69	0 36	0	0	0 38	13 19
P	C	2	720	7,512	832,900	832,067	0.1	45.3	83 8	23.4	5 34	43 6	5 40	0 86	2 24	0 34	0 76	0 17	1 27	9 77
P	C	2	720	3,399	814,242	780,252	4 8	19.8	55 8	34 5	4 95	44 1	4 84	0 77	2 42	0 32	1.03		1 35	9 38
M	C	3	720	8,760	562,900	558,059	0.9	37.9	45.0	29.6	3.13	36.9	3.59	0 78	7 06	0 17	0 37	0 12	0 66	12 09
M	C	2	720	8,760	914,300	864,300	5 5	31.6	42.4	50.9	3.23	60.7	3 71	0 87	3 82	0 91	0 34	0 06	1 31	9 71
U	C	2	720	8,760	729,970	658,898	9.7	41.7	33.5	51.3	3.76	42.5	5.53	1 13	5 52	0 25	1 15	0 10	1.50	13 68
U	C	3	700	..	629,550	579,880	7.9	38.8	....	....	4.08	52.3	5.61	1.31	5.18	0 69	1.68		2.37	14 47
U	C	2	700	.....	2,305,000	2,236,000	3.0	61.9	70.2	79.7	4.10	46.0	4.07	0 63	1 68	0 15	0.43		0 58	6 96
I	B-H&Z	2	700	5,982	2,292,000	2,250,009	1.8	55.4	84.4	65.8	5.90	63.0	4 81	0 47	1 91	0 01	0 26	0 04	0 31	7 50
U	P-T	2	660	2,920	91,800	68,859	25 0	2 1	62.6	3.8	4 34	38 3	6 93	1 07	46 00	6 78	10.13	2 89	19 80	73 80
U	S-T	3	650	4,380	31,900	28,810	9.7	1.6	49.3	1.7	3.20	63.6	7.45	2 79	64.31	1 92	0	5 35	7 27	81 22
M	C	3	630	8,760	495,000	429,120	13.3	28.2	41.3	32.4	4.38	51.5	5.15	1 08	7 98	3.45	0 22	0 02	3 69	17 90
M	C	4	620	8,760	558,084	524,025	6.1	35.4	39.4	38.9	4.00	31.4	5.34	0 62	7 45	2 01	0 60	0.19	2 80	16 21
M	C	2	615	8,760	510,000	495,640	2.8	34.3	26.5	53.2	4.49	43.7	5 97	0.96	7 02	1 14	0 31	2 98	4 43	18 38
M-W	C	3	610	8,760	451,900	446,060	1.3	29.5	.	....	2.50	38.8	2 84	1 01	7 62	0.28	0 66	0 26	1 20	12 67
I	C	1	600	8,760	726,050	706,050	2.7	18.4	72 8	28.3	6.00	66.9	5.43	1.26	5 52	0 08	0 05	0	0 13	12 34
I	C	2	600	8,760	1,259,600	1,188,400	5.7	32.7	56.2	63.4	4.98	60.9	4 62	0.52	2 85	0 30	0.50	0	0 80	8 79
U	C	1	600	.....	1,570,920	1,522,216	3.1	39.0	71.8	62.0	4.31	51.4	3.99	0.24	2.73	0.52	0 76		1 28	8.24
M-W	C	2	600	8,760	1,898,000	1,814,780	4.3	57.8	90.7	59.4	4.00	44.9	4.12	0.43	3.34	0.02	0.13	0	0 15	8.04
M-W	C	2	600	8,760	913,700	840,958	7.9	39.4	59.5	43 5	5.28	63.9	6.03	1 03	3 42	0 85	0 18	0 06	1 08	11.57
U	S-T	1	600	2,555	76,300	69,433	9.0	2.2	53 6	4.0	4.40	71.0	6.35	0.72	23.51	1.57	0	6 92	8 49	39 06
U	B-T&Z	1	600	.....	596,800	583,920	2.2	16.6	89 4	18 9	4 18	50.1	3.43	0.34	1.39	0 60	0.71	0 24	1 55	6 71
U	B-T	1	600	2,606	733,520	716,299	2.3	20.4	69.8	29.8	4 20	49.9	3.40	0.33	2.40	0.62	1.06	0.16	1.84	7.97
M	C	3	590	8,760	922,470	867,657	5.9	40.5	55.0	48.4	3.07	50.0	3.91	1.05	5.46	0.45	0.23		0.68	11.10
U	C	4	588	8,760	653,190	609,080	6.8	33.3	44.9	42.1	3.44	....	4.33	1.00	9.18	0.81	4.08	0.40	5.29	19.80
U	S-T	1	560	1,460	106,700	102,432	4 0	2.9	73.5	4.4	5.28	69.9	4.35	0.78	8.16	0.82	0	5.19	6.01	19.31
U	S-T	1	560		174,660	156,631	10.3	6.2	67 3	7 9	5.78	34.0	5.80	0.23	1.25	5.45	0.73	0.41	6.59	13.87
M	C	3	540	8,760	412,525	397,000	3.8	29.4	33 9	38 4	5 34	57.8	7.65	1.80	7 83	0.27	0.10	0.08	0.45	17.73
M-W	C	2	540	8,760	700,500	666,616	4.8	28.6	41.0	53 7	3 55	46.6	4.64	2.08	5 46	0 74	0.06	0.06	0.86	13.04
M-W	C	3	540	8,760	650,900	636,000	2.3	37.2	52.2	39.3	3.92	50.9	4.65	1.24	5.04	0.59	0.34	0.40	1.33	12.26
U	C	1	510	..	1,151,190	1,098,749	4.5	39.8	....	....	4.24	51.3	3.60	0.81	2.16	0.68	1.82		2.50	9.06
U	B-T	2	500	780	107,572	103,495	3.8	3.8	73.8	5.0	4.36	51.3	4.57	1.35	6.74	5.32	3.27	1.19	9.78	22.44
M	C	3	480	8,159	665,600	621,800	6.6	34.5	47.0	50 2	3.00	49.9	3.43	1.32	4.39	0.24	0	0	0.24	9.38
M	C	3	480	8,760	417,049	397,167	4.8	35.3	36.5	40.4	4.30	51.3	6.02	1.83	11.64	0 31	1.44	0 23	1.98	21.47
M	C	3	470	8,760	515,200	480,890	6.7	39.2	42.4	43.9	4.60	42.0	5.55	1.38	7.48	0.21	0.17	0	0.38	14.79
M	C	3	460	8,760	418,900	408,995	2.4	23.7	44.2	35.0	4.70	49.1	6.79	1.28	8 80	2.29	0.71	0 14	3.14	20.01
I	B-T&Z	2	450	2,331	428,110	422,283	1.4	22.2	60.8	26.6	3.37	64.4	4.03	0.59	1.99	0 75	0 92	0	1 67	8.28
M	C	3	450	8,760	456,140	440,760	3.4	31.6	48.8	35.3	4.81	36 0	5.26	1.24	9 39	0 67	2 90	0	3 57	19.46
U	C	3	435	8,758	778,200	738,709	5.0	38.1	46.7	65.2	3.59	40.4	4.87	0 88	6 94	2 34	2 35	0 27	4.96	17.65
M-W	C	2	430	8,760	491,320	479,720	2.3	36.9	36.5	53.2	4.72	54.2	4.85	0 76	9.08	0.94	0 87	0.04	1.85	16.54
M-W	C	2	430	8,760	515,490	471,690	8.5	38.2	40 7	50.2	4.42	55.4	6.18	0.52	6 23	0 06	0.02	0	0 08	13 01
M-W	C	3	390	8,760	490,040	486,820	0.7	24.9	43.4	49.1	5.50	34.0	7.03	0.44	9 74	0.28	0.18	0	0 46	17.67
M-W	C	2	350	8,760	315,879	301,279	4.6	25.8	32.9	46.7	3.82	47.0	4.23	2.00	10.64	0.43	0.15	0.05	0.64	17.51
M	C	3	350	8,760	412,000	400,000	2.9	29.4	41.8	47.8	4.82	38.5	7.14	0.69	6.86	0.97	0.41	0 19	1.57	16.26
U	B-T	2	345	500	66,822	65,845	1.8	7.6	67.4	4.9	4.59	50.4	4.61	0.96	7 28	3.31	12.98	0 06	16.35	29.20
U	C	2	330	8,760	412,136	369,378	10.5	42.8	40.8	51.9	3.25	52.0	5.36	1.71	7.39	1.79	6 12	0 70	8 60	23.07
M	C	3	320	8,760	262,100	257,000	2.0	26.0	39.6	35.2	7.35	59.0	9.59	1.41	11.67	0.19	0 70	0.14	1.03	23.70
M-W	C-Z	1	320	8,760	521,127	421,352	19.2	33.1	28.4	97.5	4.32	60.6	7.27	0.47	11.29	0 54	0	0.05	0.59	19.62
U	C	2	315	..	203,800	186,510	8.5	31.0	....	....	4.14	40.0	7.29	2.13	10.88	0.77	5.16		5.93	26.23
U	C	4	305	8,760	409,926	314,646	23.2	42.5	55.3	40.6	3.96	48.7	6.02	1.73	8.09	0.94	1 14	0.44	2.52	18.36
J	C	2	300	6,630	254,000	251,413	1.0	....	27.2	52.6	3 64	37.5	3.63	0 50	3 73	0.19	0 02	0	0.21	8.07
U	C	2	270	8,760	211,600	172,400	18.5	39.6	26.7	49.6	3.12	46.4	7.17	3.13	16.40	3.81	6.85	1.00	11.66	38.36
I	C	1	240	1,809	84,090	79,570	5.4	6.0	28.8	20.7	4.50	50.8	6.34	1.13	4.52	0.98	8.74		9.72	21 71
I	C	1	240	..	235,000	210,000	10 6	19.9	74.1	22.5	4.61	41.7	3 95	1.19	1.43	0.36	0.95	0	1 31	7.88
U	B-T	1	225	8,760	329,143	317,143	3.6	23.5	66.8	37.3	3 43	50.1	3.99	0.93	3.60	0.16	0.23	0 21	0.60	9.12
U	S-	1	225	2,160	29,000	26,851	7.4	1.8	48.5	4.5	4.29	45.7	5.07	0.60	5.59	0.75	0.82	0.19	1.76	13.02
M	C	4	212½	8,760	144,230	139,730	2.9	26.6	....	....	3.69	53.2	6.81	2.37	13.43	2.00	0.34	1 20	3.54	26.15
M-W	C	1	200	8,760	424,400	408,307	3.8	42.1	64.0	56.5	5.00	42.9	6.24	0.64	2.74	.....	0.26	....	0.97	10.59
U	S-T	2	175	68	2,135	1,892	11.4	0.2	53.2	0.4	6.03	50.0	16.00	3.17	38.34	20.20	0	37.20	57.40	114 91
M	S-H	1	120	8,736	8,990	8,074	10.2	....	11.1	11.4	5.39	55.5	14.62	4.34	21.92	12.87	9.91	8.55	31.33	72.21
M	C	2	100	8,760	58,550	45,350	22.6	29.1	....	....	6.36	65.4	15.52	6.22	39.85	3.60	0.18	0	3.78	65.37

NOTES—Character of Plant
U—Private Power Company
P—Private Pumping Company
M—Municipal Power Plant
W—Municipal Pumping Plant
I—Industrial Power Plant
B—City Building Power Plant

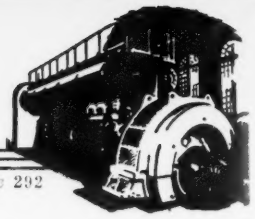
Type of Load
C—Complete Power
B—Base Load
S—Stand by
P—Peak Load
V—Type Varied during Period
—T—Supplemented by Transmission Line
—H—Supplemented by Hydro-Electric Units
—Z—Supplemented by Steam Units
—G—Supplemented by Gas Engines

Lettered Notes
a—Attendance Cost includes no Repair Labor; Repair Costs include All Repair Labor.
b—Steam Plant used in Emergencies Only.
c—No Cost included for Water, which goes to House Supply.
d—K.W. Rating; Direct Current.
e—No Deduction made for Attendance of Ice Plant.
f—Does not include $1,885 for Cast Iron Piston Heads to Replace Steel; Change made for Operating Reasons and Charged to Capital Account.
g—No Deduction made for Attendance of Water Pumping Plant.

Running-plant-capacity factor, per cent = Plant output in gross kwhr × 100 / Total rated kwhr of individual units

Plant-service factor, per cent = Total rated kwhr of individual units × 100 / Total installed kw × number of hours in period

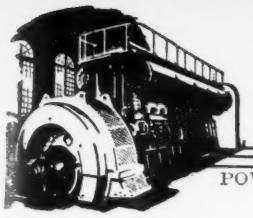
Annual-plant-load factor, per cent = Plant output in gross kwhr × 100 / Peak load in kw × number of hours in period



178 TYPICAL NEW PLANTS

Installed since Jan. 1, 1934

Owner	Location	Service	Unit Driven	Engine Builder	No. of Engines	Hp. per Engine	R.P.M.	No. Cyl.	Cyl. Bore, In.	Cyl. Stroke	Cycle	Starting Method	Fuel Injection	Fuel, lb. per b. hp. hr.
Puget Sound Nav. Co	Seattle, Wash.	Ferry	Prop.	BuS	1	3,000	230	10	19½	27	2	A	S	0.38
			Alt.	BuS	1	600	360	8	13	17	4	A	S	0.40
Village of Freeport	New York	Mun. Add.	Alt.	BuS	1	3,000	240	10	19½	27	2	A	S	0.40
U. S. Engineer Corps	Louisville, Ky	Dredge	Pump	BuS	1	1,700	250	6	19½	27	2	A	S	0.41
City of Bryan	Ohio	Mun. Add.	Gen.	Nor	1	1,500	....	6	...	...	2	A	A	....
U. S. Indian Irrig. Svce	Coolidge, Ariz.	Pwr.	Gen.	Nor.	2	1,300	....	7	...	...	2	A	S	....
City of Sikeston	Mo.	Mun.	Gen.	Nor	1	1,250	....	5	...	...	2	A	S	....
City of Grand Haven	Mich.	Mun. Add.	Gen.	DLV	1	1,140	200	6	22	30	4	A	S	....
Imperial Valley	Rawleigh, Cal.	Irrig. Pwr.	Gen.	HOR	3	1,000	240	3	21	27½	2	A	S	....
Tex-O-Can Flour Mills Co	Dallas, Tex.	Pwr.	Shaft	Nor	1	1,000	....	5	...	...	2	A	A	....
City of Russell	Kans.	Mun. Add.	Gen.	DLV	1	1,000	240	8	17	24	4	A	S	0.45
Higginsville	Mo.	Mun. Add.	Gen.	DLV	1	1,000	200	5	22	30	4	A	S	0.4
City of Neodesha	Kans.	Mun. Add.	Gen.	Nor	1	1,000	....	4	...	...	2	A	A	....
City of Oberlin	Ohio	Mun. Pwr.	Alt.	FM	2	875	300	5	16	20	2	A	S	0.45
					1	600	400	6	12	15				0.48
Pevely Dairy Co	St. Louis, Mo.	Dairy Add.	Alt.	BuS	2	875	300	5	15⅛	21	2	A	S	0.39
Litchfield	Minn.	Mun. Add.	Alt.	FM	1	875	300	5	16	20	2	A	S	....
Forrest City Cotton Mills	Forrest City, Ark.	Plt. Pwr.	Gen.	Nor	1	832	....	6	...	...	4	A	S	....
					1	600	....	4	...	...	4	A	S	....
					1	800	277	6	14¼	18	2	A	A	....
Elko Lamoille Pwr. Co	Elko, Nev.	Lt. & Pwr.	Gen.	BuS	2	480	360	6	13	17	4	A	A	....
					1	365	225	4	16¼	24	4	A	A	....
Paterson Milk & Crm. Co	Paterson, N. J.	Plt. Pwr.	Comp. & Shft.	Bud	1	800	860	4	6½	8½	4	A	S	....
Sterling Crushed Stone Co	Sterling, Mass.	Plt. Pwr.	Gen.	Win	1	800	450	8	14	16	4	A	A	....
City of Pawhuska	Pawhuska, Okla.	Lt. & Wtr.	Gen.	Ful	1	300	200	3	16	24	4	A	A	0.5
				Ful	2	285	200	3	16	24	4			
				BuS	1	750	257	5	14⅜	21	2			
New Castle	Ind.	Mun. Add.	Gen.	DLV	1	750	240	6	17½	24	4	A	S	0.4
Independence	Iowa	Mun. Add.	Alt.	Wor	1	750	257	3	17	25	2	A	S	0.4
Comp. Elect. de Port-au-Prince	Haiti	Pwr	Gen.	DLV	1	750	180	4	22	30	4	A	..	..
Estherville	Iowa	Mun. Add.	Alt.	Wor	1	750	257	3	17	25	2	A	S	0.4
Tipton	Ind.	Mun.	Gen.	Win	3	700	450	7	14	16	4	A	S	..
Comp. Minera S. Maria del Oro	Durango, Mex.	Pwr.	Gen.	DLV	1	660	240	6	17	24	4	A	S	0.4
City of Stewart	B. C.	Mun.	Gen.	FM	3	630	300	6	14	17	2	A	S	0.4
Wabasha Roller Mills Co	Wabasha, Minn.	Pwr	Alt.	FM	1	630	300	6	14	17	2	A	S	0.40
					1	140	300	2	14	17	2	A	S	
Grand Coulee Dam	Wash.	Pwr.	Alt.	FM	1	630	300	6	14	17	2	A	S	0.40
City of St. Hyacinthe	Que.	Mun. Pwr.	Alt.	MeI	4	600	360	8	12½	18	4	A	S	0.37
Rule Jayton Cotton Oil Co	Stanford, Tex.	Oil	Mill	BuS	1	600	225	6	16½	23	4	A	A	0.41
City of Ruston	La.	Mun. Pwr.	Alt.	BuS	1	600	225	6	16½	23	4	A	A	0.41
Singer Bldg	New York, N. Y.	Pwr. Add.	W. Gen.	Win	1	525	375	6	14	16	4	A	S	0.39
Hill Dredge Co	Arvenda, S. C.	Dredge	Gen.	MeI	1	510	600	6	12½	13	4	A	S	0.39
City of Frederick	Okla.	Mun. Pwr.	Gen.	?	3	500	....	..	...	...	..	..	..	.....
100-475 Hp. per Engine														
Navehood Bros	Milton, Pa.	Quarry	Gen.	Sup.	1	475	300	6	14	13	4	A	S	....
New Orleans Cold Stg	New Orleans, La	Refrig.	Gen.	MeI	3	460	300	6	12½	22	4	A	S	0.39
City of Pawnee	Okla.	Mun. Pwr.	Gen.	MeI	2	450	360	6	12½	18	4	A	S	0.39
Fruen Milling Co	Minneapolis, Minn.	Pwr.	Alt.	FM	1	450	257	5	14	17	2	A	S	....
City of Ord	Neb.	Mun. Pwr.	Gen.	IR	1	440	225	4	17¾	22	4	A	S	0.40
					1	330		3						
Mt. Rainier Nat'l Pk	Sunrise, Wash.	Pumps	Gen.	Was	1	440	600	6	12	18	4	A	S	0.076
					1	325	460	6	12	18				
Atkinson Dredge Co	Norfolk, Va.	Dredge	Pump	MeI	1	430	500	6	12½	13	4	A	S	0.39
City of Kennett	Mo.	Mun. Pwr.	Alt.	FM	1	420	300	5	14	17	2	A	S	0.45
					2	350	300	4	14	17	2	A	S	
Cargill Warehouse Co	Minneapolis, Minn.	Elev.	Alt.	FM	1	420	300	6	14	17	2	A	S	0.45
					1	210	300	3	14	17	2	A	S	
City of California	Mo.	Mun. Pwr.	Alt.	FM	1	420	300	6	14	17	2	A	S	0.55
					2	350	300	5	14	17	2	A	S	0.55
Town of Culpeper	Va.	Mun.	Gen.	DLV	2	400	300	5	15	18½	4	A	S	....
					1	240	300	3	15	18½				
City of Villisca	Iowa	Mun. Pwr.	Alt.	DLV	2	400	300	5	15	18½	4	A	S	....
Amendt Milling Co	Monroe, Mich.	Mill	.....	Buc	1	375	360	5	13½	15½	4	A	S	....
Minden	Neb.	Mun. Pwr.	Gen.	MeI	1	375	360	5	12½	18	4	A	S	0.37
U. S. Gov't	Shiprock, N. M.	C. S.	Gen.	Sup	2	350	360	6	12½	15	4	A	S	....
City of Lamoni	Iowa	Mun. Pwr.	Alt.	FM	1	350	300	5	14	17	2	A	S	0.38
					1	280		4						
Gillespie Land & Irrig. Co	Gila Bend, Ariz.	Feed	Mill	Sup.	1	350	600	8	9	12	4	A	S	....
City of St. Cloud	Fla.	Mun. Add.	Gen.	Sup	1	315	300	6	12½	15	4	A	S	....
City of Horning	Okla.	Mun. Pwr.	Gen.	?	3	300	....	..	...	...	..	..	..	.....
Monroe City	Mo.	Mun. Pwr.	Gen.	Wor	2	300	300	4	13½	17½	4	A	S	....
				FM	1	240	300	4	14	17	2	A	S	....
Southwest Cotton Oil Co	Litchfield Park, Ariz.	Ranch / Standby	Gen.	Win	1	300	500	8	8½	12	4	A	S	....
					1	100		3						
Tygart Limestone Co	Lawton, Ky.	Quarry	Gen.	Buc	1	300	400	8	9½	14	4	A	S	....
City of Corning	Iowa	Mun. Pwr.	Alt.	FM	1	280	300	5	14	17	2	A	S	0.38
					2	210		3						
Wis. Oxygen-Hydrogen Co	Kenosha, Wis.	Pwr.	Alt.	FM	1	280	300	4	14	17	2	A	S	0.45
					1	210	300	3	14	17				
City of Kewanee	Ill.	Water & Lt.	Alt.	FM	1	280	300	4	14	17	2	A	S	0.44
Molokai Elec. Co	Molokai, T. H.	C. S. Add	Alt.	AI	1	275	300	6	11½	15	4	A	S	0.41
City of Augusta	Kans.	Mun. Add.	Gen.	AI	1	275	300	6	11½	15	4	A	S	0.4
City of Bountiful	Utah	Mun. Lt.	Gen.	Buc	2	270	400	5	9½	14	4	A	S	....
					1	140	400	3						
Gold Hill Mines, Inc	Salmon, Idaho	Mine	.....	Buc	1	262½	400	7	9½	14	4	A	S	....
Union Quarries Co	Van Wert, O.	Quarry	Gen.	Buc	1	260	200	2	19	23	2	A	S	....
White Water Flour Mills Co	White Water, Kans.	Pwr.	Gen.	DLV	1	260	277	4	14½	18	4	A	S	....
Boriana Mining Co	Los Angeles, Cal.	Mine	Gen.	Sup	1	260	550	8	8½	11	4	A	S	....
U. S. Navy	Brooklyn, N. Y.	Crane	Gen.	MeI	2	250	685	5	9½	10½	4	A	S	0.39
Ohio Wax Paper Co	Columbus, Ohio	Plt. Pwr.	Gen.	Win	1	250	400	6	...	...	4	A	S	....
					1	165	400	4	...	...	4	A	S	....
Barton Mines Corp	North Creek, N. Y.	Mine	Gen.	DLV	1	240	600	6	9	11	4	A	..	....
Geary Milling & Elev. Co	Geary, Okla.	Mill	.....	Buc	1	240	300	3	13	18	4	A	S	....
Okeene Mllg. Co	Okeene, Okla.	Flour Mill	Alt.	AI	1	230	300	4	12½	16	4	A	S	0.41
Avondale Farms Dairies	Bethlehem, Pa.	Refrig.	Comp.	Buc	1	225	400	6	9½	14	4	A	S	....
					1	112½	400	3	9½	14	4	A	S	....
					1	75	400	2	9½	14	4	A	S	....
City of Gowrie	Iowa	Mun. Pwr.	Alt.	Wor	2	225	327	3	13¼	17½	4	A	S	0.39
City of West Point	Neb.	Mun. Add.	Alt.	BuS	1	225	360	3	13	17	4	A	S	0.40
Gaidis Artificial Ice Co	Van Wert, O.	Ice	Comp.	Buc	1	225	400	6	9½	14	4	A	S	....
Willey-Ruckstuhl Co	Cincinnati, O.	Sand & Gravel	.....	Buc	1	225	400	6	9½	14	4	A	S	....
General Mills	Wichita, Kans.	Mill	Gen.	MeI	1	225	360	3	12½	18	4	A	S	0.39



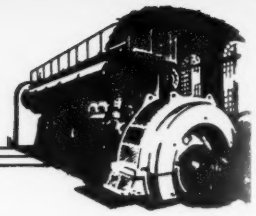
DIESEL ENGINE DATA

Owner	Location	Service	Unit Driven	Engine Builder	No. of Engines	Hp. per Engine	R.P.M.	No. Cyl.	Cyl. Bore, In.	Cyl. Stroke	Cycle	Starting Method	Fuel Injection	Fuel, lb./b. hp.hr.
Ohio Mines Corp.	Gold Point, Nev.	Mine	Gen.	AI	2	200	514	6	9	10½	4	A	S	0.45
Rose Spring Drill. Co.	Wichita, Kans.	Oil Field	Drill	AI	2	200	500	6	9	10½	4	A	S	0.45
City of Glidden	Iowa	Mun. Pwr.	Alt.	Nor	1	200	400	4	10½	15	4	A	S	0.40
					1	150	400	3						
U. S. Marine Hospital	Fort Stanton, N. M.	Pwr.	Gen.	Sup	1	200	450	6	9	12	4	A	S	....
					1	100	450	3						
Ferris & Marchbank	Daly City, Cal.	Dredge	Gen. Shaft	AI	1	200	514	6	9	10½	4	A	S	0.45
					1	45	600	3	6½	8½				
Chi. Peoria & Western R. R.	Peoria, Ill.	R. R.	Crane	Sup	1	175	600	4	9	12	4	A	S	....
Home Ice Co.	New Orleans, La.	Ice	Comp.	Buc	2	150	400	2	9½	14	4	A	S	....
Turecamo Bros. Contrg. Co.	Brooklyn, N. Y.	Plt. Pwr.	Alt.	Win	2	150	450	3	10	14	4	A	S	....
Wheeler Shipyard	Brooklyn, N. Y.	Plt. Pwr.	Alt.	Wol	1	150	400	4	9¼	14	4	A	S	0.44
					1	40	360	1						
John Royle & Sons	Paterson, N. J.	Plt. Pwr.	Gen.	McI	1	150	514	5	9½	10½	4	A	S	0.39
Brickley & Ayers	Osceola, Ark.	Lbr. & Gin	Shaft	Buc	1	150	400	4	9½	14	4	A	S	....
Edwards Ice Co.	Edwardsville, Ill.	Ice	Comp.	Buc	1	150	400	4	9½	14	4	A	S	....
Mt. Vernon Furnace & Mfg. Co.	Mt. Vernon, Ill.	Plt. Pwr	Gen.	Wor	1	150	400	3	10½	14½	4	A	S	0.41
Reidsville Ice & Coal Co.	Reidsville, N. C.	Ice	Comp.	Buc	1	150	400	4	9½	14	4	A	S	....
Sears Roebuck Co.	Camden, N. J.	Store	Alt.	FM	2	140	300	2	14	17	2	A	S	0.45
Lufkin Ice Co.	Lufkin, Tex.	Ice Plt.	Comp. & Alt.	FM	2	140	300	2	14	17	2	A	S	0.45
Wyoming Ice & Cold Stor. Co.	Wyoming, Del.	Ice	Comp.	Sup	1	140	600	4	8½	11	4	A	S	....
Folmer Ice Cream Co.	Hanover, Pa.	Ice	Gen.	Sup	1	140	600	4	8½	11	4	A	S	....
Mitchel & Pierson, Inc.	Philadelphia, Pa.	.....	Gen.	Sup	1	140	600	4	8½	11	4	A	S	....
Blosser Stone Co.	Paulding, Ohio	Quarry	Gen.	Buc	1	125	200	1	19	23	2	A	S	....
Oregon King Mines	Madras, Ore.	Mine	Gen. & Comp.	AI	2	120	650	6	7	8½	4	A	S	0.45
Cia. Minera Asarco.	Taviche, Oaxaca, Mex.	Mine	Comp.	AI	1	120	650	6	7	8½	4	A	S	0.45
Greensburg Ice Co.	Greensburg, Ind.	Ice	Comp.	Buc	1	112½	400	3	9½	14	4	A	S	....
					1	75	400	2						
Planters Gin Co.	Tuckerman, Ark.	Gin	Shaft	Buc	1	112½	400	3	9½	14	4	A	S	....
Pemberville Elev. Co.	Pemberville, O.	Mill	.....	Buc	1	112½	400	3	9½	14	4	A	S	....
Magnetic Ice & Bottling Co.	Lebanon, Mo.	Ice	Comp.	Buc	1	112½	400	3	9½	14	4	A	S	....
Fine Arts Furniture Co.	Grand Rapids, Mich.	Plt.	Gen.	Buc	1	112½	400	3	9½	14	4	A	S	....
Cheyenne Indian Agcy.	Cheyenne Agency, S. D.	Lt. & Pwr.	Alt.	FM	1	110	360	2	12	15	2	A	S	....
					1	55		1						
Worthington Ranch	Bakersfield, Cal.	Irrig. Add.	Pump	FM	1	110	300	2	14	17	2	A	S	0.45
Forbes Ranch	Coachella Valley, Cal.	Irrig. Water	Pump	FM	1	110	300	2	14	17	2	A	S	0.45
Hayti Ice & Cold Storage Co.	Hayti, Mo.	Pwr.	Alt. & Comp.	FM	1	110	300	2	14	17	2	A	S	....
Springdale Ice & Coal Co.	Springdale, Conn.	Ice Plt.	Alt. & Comp.	AI	1	105	300	3	10	13	4	A	S	0.41
Huntington	N. Y.	Wtr.	Pump	Ame	1	100	1,000	4	5½	7	4	A	S	....
Medford	Mass.	Wtr.	Pump	Wor	1	100	514	..	..	..	..	..	..	....
G. E. Spitzer	Parma, Mo.	Gin	Shaft	Buc	1	100	514	5	7⅛	10½	4	A	S	....
Less than 100 Hp. per Engine														
Superior Ice Co.	Superior, Ariz.	Ice	Comp.	Sup	1	90	700	4	7	9	4	A	S	....
Raton Milling & Elev. Co.	Raton, N. M.	Mill	Shaft	Buc	1	90	240	1	16	20	2	A	S	....
N. Y. Cordage & Cable Co., Inc.	Jamaica, N. Y.	Plt.	Gen.	AI	2	80	650	4	7	8½	4	A	S	0.45
Mt. Holly Ice Co.	Mt. Holly, N. C.	Ice	Comp.	Buc	1	80	514	4	7½	10½	4	A	S	....
City Ice Co.	Elkhart, Ind.	Ice	Comp.	Buc	1	80	514	4	7½	10½	4	A	S	....
Catawba Cty. Ice & Fuel Co.	Conover, N. C.	Ice	Comp.	Buc	1	80	514	4	7½	10½	4	A	S	....
Town of Laurel	Md.	Water	Pump	AI	1	80	450–650	4	7	8½	4	A	S	0.42
G. M. Anthony	Strausstown, Pa.	Mill	Shaft	Buc	1	80	514	4	7½	10½	4	A	S	....
Aaron Mills	Martinsville, Va.	Mill	Shaft	Buc	1	80	514	4	7½	10½	4	A	S	....
Polhemus Memorial Clinic	Brooklyn, N. Y.	Pwr.	Gen.	AI	1	75	600	4	7	8½	4	A	S	0.45
Piedman Land & Cattle Co.	San Simeon, Cal.	Belt	Hammer Mill	Cat	1	75	820	6	5¼	8	4	G	S	....
Pan-American Airways	Midway Island	Field Ltg.	Gen.	Cat	2	75	820	6	5¼	8	4	G	S	....
Pan-American Airways	Wake Island	Field Ltg.	Gen.	Cat	2	75	820	6	5¼	8	4	G	S	....
Meadowbrook Country Club.	Meadowbrook, N. Y.	Lt. & Pump	Gen.	Wau	2	75	....	..	....	....	..	..	..	....
Daisetta Ice Co.	Daisetta, Tex.	Plt.	Comp. & Gen.	Cat	1	75	820	6	5¼	8	4	G	S	....
J. W. Weller Sons	E. Fultonham, O.	Mill	Shaft	Buc	1	75	400	2	9½	14	4	A	S	....
A. H. Randall Mill. Co.	Tekonsha, Mich.	Mill	.....	Buc	1	75	277	1	15	18	2	A	S	....
Tri-State Mill. Co.	Rapid City, S. C.	Mill	.....	Buc	1	75	400	2	9½	14	4	A	S	....
C. E. Kiff, Inc.	Delhi, N. Y.	Mill	.....	Buc	1	75	400	2	9½	14	4	A	S	....
Alaska Sou. Pack. Co.	Seattle, Wash.	Cannery	Shaft	Sup	1	65	700	3	7	9	4	A	S	....
Gessell Milling Co.	Malta, O.	Mill	.....	Buc	1	65	260	1	14	18	2	A	S	....
Village of Hempstead	N. Y.	Water	Pumps	FM	3	60	1,200	6	4½	6	4	A	S	....
Gulf Refining Co.	Kearney, N. J.	Ref.	Pumps	Sup	2	60	600	3	7	9	4	A	S	....
A. R. McCarty	Chambersburg, Pa.	Ice	Comp.	Buc	1	60	514	3	7⅛	10½	4	A	S	....
Tompkins Dry Goods Co.	Middletown, N. Y.	Pwr.	Gen.	FM	1	60	1,200	6	4½	6	4	A	S	0.50
					1	40		4						
Western Meat Co.	Little Rock, Ark.	Refrig.	Gen.	AI	1	60	450	3	7½	10½	4	A	S	0.45
Std. Oil Co. of Cal.	Bitter Water, Cal.	Pipeline	Gen.	AI	1	60	720	4	6	8	4	A	S	0.45
A. J. Balshi	Catawissa, Pa.	Mill	Shaft	Buc	1	60	514	3	7½	10½	4	A	S	....
C. D. Fletcher	Ayer, Mass.	Ice Plt.	Comp.	AI	1	60	600	4	6½	8½	4	A	S	0.45
Jackson Exch. & Mill.	Jackson, Ohio	Mill	Shaft	Buc	1	60	514	3	7½	10½	4	A	S	....
Sperry Gerard Mill. Co.	Rochester, N. Y.	Flour Mill	Shaft	FM	1	60	1,200	6	4½	6	4	A	S	0.40
S & S Paper Machy. Co.	Brooklyn, N. Y.	Plt. Pwr.	Gen.	FM	1	60	1,200	6	4½	6	4	A	S	0.40
Beam Mllg. Co.	Hemlock, N. Y.	Milling	Shaft	FM	1	60	1,200	6	4½	6	4	A	S	0.40
Houchin Farms	Bakersfield, Cal.	Irrig.	Pump	FM	1	55	360	1	12	15	2	A	S	....
Johnson & Ashman	Freeland, Pa.	Ice Plt.	Comp.	RuH	1	48	290	1	10½	19½	4	A	S	0.4
A. V. Aldrete	Mexicali, Mex.	Ice Plt.	Comp.	AI	1	45	650	3	6½	8½	4	A	S	0.45
Pippert Property	Visalia, Cal.	Water	Pump	FM	1	40	1,200	4	4½	6	4	H	S	....
Martin Century Dairy Farm.	Landsdale, Pa.	Plt. Refrig.	Comp.	FM	1	40	1,200	4	4½	6	4	H	S	....
Producers Creamery Co.	Olney, Ill.	Plt. Pwr.	Alt.	FM	1	40	1,200	4	4½	6	4	H	S	....
Ciabarri Ranch	So. Cal.	Irrig.	Pump	FM	1	30	1,200	3	4½	6	4	H	S	....
Miss. Transient Bur.	Jackson, Miss.	Pwr.	Alt.	FM	1	30	1,200	3	4½	6	4	H	S	....
S. S. Hill Ranch	Barstow, Cal.	Add.	Pump	FM	1	30	1,200	3	4½	6	4	H	S	....
Village of Port Chester	N. Y.	Sewage	Pump	Lis	1	27	1,000	3	4½	5½	4	A	S	0.44
Mansert Ice Cream Co.	N. Adams, Mass.	Refrig.	Comp.	Lis	1	27	1,000	3	4½	5½	4	H	S	0.44
Smart's Oil Co.	Waltham, Mass.	Lights	Alt.	FM	1	20	1,200	2	4½	6	4	H	S	....
Karels Serv. Sta.	N. Bergen, N. J.	Lt. & Pwr.	Gen.	Lis	1	18	1,000	2	4½	5½	4	H	S	0.44
Central Lunch	Meriden, Conn.	Lts.	Gen.	Lis	1	18	1,000	2	4½	5½	4	H	S	0.44
875 Park Ave.	New York, N. Y.	Refrig.	Comp.	Lis	1	18	1,000	2	4½	5½	4	H	S	0.44
Somerset Bus Co.	Mountain View, N. J.	Garage	Gen.	Lis	1	16	1,200	2	4½	4¾	4	H	S	0.44
Brooks & Sprague	Lynn, Mass.	Tanks	Pump	Lis	1	16	1,200	2	4½	4¾	4	H	S	0.44
Goslin Dairy Co.	Chicopee, Mass	Dairy	Comp.	Lis	1	16	1,200	2	4½	4¾	4	H	S	0.44
Max Yeltson	Newport, R. I.	Dairy	Gen.	Lis	1	16	1,200	2	4½	4¾	4	H	S	0.48
Colin K. Lee	Pittsburgh, Pa.	Hse. Lt.	Gen.	Lis	1	16	1,200	2	4½	4¾	4	H	S	0.44
Waterville Mfg. Co.	Waterville, Conn.	Plt. Pwr.	Shaft	Lis	1	16	1,200	2	4½	4¾	4	H	S	0.44
Princeton Univ.	Princeton, N. J.	Lab.	Test	McI	1	15	800	1	5½	9	4	H	S	....
Std. Oil of N. J.	Venezuela	Aux.	Gen.	Lis	1	14	1,000	2	4½	4¾	4	H	S	0.44
W. G. Barber	N. Adams, Mass.	Plt. Pwr.	Shaft	RuH	1	13	360	1	7	13½	4	H	S	0.42
A. M. Wagenhorst	Mertztown, Pa.	Mun. Lt.	Gen.	RuH	1	13	360	1	7	13½	4	H	S	0.42
Major's Garage	Asbury Park, N. J.	Lt. & Pwr.	Gen.	Lis	1	8	1,200	1	4½	4¾	4	H	S	0.44
Golden Lad Dairy	Verona, N. J.	Dairy	Gen.-Comp.	Lis	1	8	1,200	1	4½	4¾	4	H	S	0.44
Milton Chase	Homestead, R. I.	Mun. Lt.	Gen.	Lis	1	8	1,200	1	4½	4¾	4	H	S	0.48
Wharf Machine Co.	Boston, Mass.	Aux.	Gen.	Lis	1	7	1,000	1	4½	4¾	4	H	S	0.44
Elmer Hurst	Ithaca, N. Y.	Store Lt.	Gen.	Lis	1	5	600	1	4½	5½	4	H	S	0.46
R. E. Parker	Brooklyn, N. Y.	Plt. Pwr.	Gen.	Lis	1	3	600	1	4¼	5½	4	H	S	0.48
Atlantic Lobster Co.	Boston, Mass.	Tanks	Pump	Lis	1	3	600	1	4¼	5½	4	H	S	0.48

Abbreviations—AI—Atlas Imperial, Ame—American, Buc—Buckeye, Bud—Buda, BuS—Busch-Sulzer, Cat—Caterpillar, DLV—DeLaVergne, FM—Fairbanks Morse, FMH—Fairbanks Morse horizontal, Ful—Fulton, HOR—Hooven, Owens, Rentschler, IR—Ingersoll-Rand, Lis—Lister, McI—McIntosh and Seymour, Nor—Nordberg, RuH—Ruston horiz., Sup—Superior, Was—Washington, Win—Winton, Wol—Wolverine, Wor—Worthington, Wau—Waukesha. Add.—addition, Alt.—alternator, C. S.—central station, Gen.—generator, Hse.—house, Irrig.—irrigation, Lt.—light, Mun.—municipal, Plt.—plant, Pwr.—power, Refrig.—refrigeration, Wtr.—water.

Under fuel injection—S is solid, A is air.

Under starting, A is air, H hand, E electric, G gasoline.



TULSA MEETING STRESSES

Eighth National Meeting of A.S.M.E. Division attended by more than 160 engineers. Fuel injection, high-speed engines and insurance among subjects discussed

THE Eighth National Meeting of the Oil & Gas Power Division, A.S.M.E., was held at the Hotel Mayo, Tulsa, Okla., May 8-11. Over 160 engineers attended the sessions.

High-Speed Diesels

The meeting opened with a paper by J. B. Harshman, Stanolind Pipe Line Co., on "Operating Experience in Use of High-Speed Diesels on Pipe Lines." Mr. Harshman described his experience with two 300-hp., 4-cycle, mechanical-injection engines rated at 600 to 750 r.p.m. One of these engines, located in East Texas, is burning a composite crude with fair success except that combustion has not been especially good, resulting in the need for frequent cleaning out of carbon. The other engine, operated on West Kansas sour crude containing hydrogen-sulphide gas, ran into excessive maintenance troubles, necessitating four complete renewals of pistons and rings and much replacement of injection system parts. Mr. Harshman laid the trouble to the sulphur in the crude, particularly the hydrogen sulphide gas. He suggested that some better material than aluminum must be found for pistons for high-speed engines and more resistive alloys were needed for injection system parts than metals now used. The older type, slow-speed Diesel has been using sour crude with success, and the newer, high-speed units must be designed to do so if they are to survive for out-of-the-way locations where it is inconvenient to ship in refined fuel oil.

Discussion brought out that design has been improved since the Stanolind engines were built. Aluminum pistons have been manufactured commercially with cast-in aluminum-bronze ring bands which have eliminated all but normal ring-groove wear in many instances. Combustion has been improved by a number of refinements in chamber design and injection systems.

Some discussors felt that Mr. Harshman had not exhausted the possibilities in an effort to clear up the trouble. The crude fuel had been neither heated nor centrifuged in an effort to drive off hydrogen sulphide and water. Crank-case dilution by fuel had not been measured. Apparently no great effort had been made to clean the fuel of physical impurities, such as sand, an active eroding agent in most crude oils.

Fuel Characteristics

Wednesday afternoon one of the most significant papers on Diesel fuel that has been heard in several years was delivered by W. F. Joachim, Atlantic Refining Co., "The Characteristics of Diesel Fuel Oil." Mr. Joachim described his work in Philadelphia, using a 50-kw. Cooper-Bessemer marine diesel generating set and a Waukesha C. F. R. engine with both the old, open-type head and the new, Comet-type head.

By means of this equipment, exact correlations were established between critical compression ratios and cetene ratings on the one hand and performance in the Cooper-Bessemer engine on the other. A careful analysis was made of the performance of the latter by means of indicator cards, an accurate smoke meter (although so little smoke was produced, even at 110 lb. bmep., that these readings were of questionable value), photomicrographs of carbon formations, and pyrometer readings of temperatures at various points, all of this at various loads from no-load to 20% over-load.

Information was accumulated for straight-run distillates, cracked distillates, heavy residues, and various blends. Results were presented by a series of curves in which were demonstrated correlations between many fuel properties and engine performance.

One interesting value proposed by Mr. Joachim is his so-called "measured knock," a function of the multiplication of the explosion pressure rise in lb. per sq.in. and the burning rate in lb. per sq.in. increase of pressure per degree of crank rotation. This factor holds promise as a quantitative measure of engine "roughness"—formerly a property "evaluated" by the quite qualitative and approximate human ear.

In discussion, Mr. Joachim introduced evidence to show that nozzle temperatures probably do not exceed 550 deg. F. He substantiated one commentator's point that there is a critical temperature range for carbon deposits, from approximately 350 to 750 deg. F., and that below or above this range much less depositing is experienced. Aluminum pistons, on which tests were run, had the effect of lowering compression pressures slightly with somewhat less carbon deposited. Tests had also been run using crude for fuel and, while all adverse symptoms were more marked, the engine never failed to complete the tests under the loads scheduled.

Pumping Problems

Thursday morning was devoted to well drilling and pumping problems, with one paper, "The Design of a Portable Rotary Drilling Machine," by J. A. Niles, Stanolind Oil & Gas Co. and one—"Central Power Plants Transmitting Power Mechanically to Wells"—by Austin Allen, Phillips Petroleum Co.

Thursday afternoon an inspection trip was made to the Hominy Pumping Station of the Stanolind Pipe Line and to several well-drilling operations where diesels were used.

Friday morning, Paul D. Cornelius, Sullivan Machinery Co., read a paper on "Central Power Plants Transmitting Power Pneumatically to Wells." Mr. Cornelius described a typical layout for nine wells, requiring 2,231,000 cu.ft. of air or gas in each 24 hours of operation.

Glenver McConnell, Shell Petroleum Co., in "Diesel and Gas Individual Well-Pumping Units," called attention to changed requirements brought about by proration, deeper wells, and wider spacings. The individual pumping unit is more adaptable than central powers to these requirements.

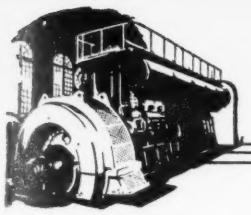
For years the dual-purpose unit, i.e., a power unit adapted both to low power pumping duty and the higher power servicing job, have been popular. Engines so used must have a wide range of power and speed. Often the effort to meet both duties has not been wholly satisfactory. There has lately been a trend away from this type of equipment to smaller, single-purpose pumping units. Only the necessity for pumping "potentials" for proration remains to justify the installation of larger horsepowers.

Pumping Engines

Most of the pumping engines used today are horizontal, single-cylinder units, 2- or 4-cycle, made to run on gas, fuel oil or crude oil. The use of crude oil as fuel for high-compression engines is favored by some, but judgment should be suspended until more experience is gained. Meanwhile refined fuel oil is known to cause less maintenance and to enable engines to operate at much higher fuel economy.

Multi-cylinder, vertical engines of fairly high speed, pumping through double reduction gearing, are coming into use. Some of these are of cheap design and construction, after automotive practice. Oil-field buyers will do well to receive any but the best of these with skepticism, for only the best construction can survive under the conditions obtaining.

Previously the wide range of speed and power required for dual-purpose units retarded the adoption of the closed cooling system. Such systems are feasible for the smaller, single-purpose units, and will have to be used for multi-cylinder vertical units to avoid the high maintenance that will result



DIESELS IN THE OIL FIELDS

Reported for POWER

By M. J. Reed

Secretary, Diesel Engine Manufacturers' Assn.

with that type of unit if operated with an open cooling system on the kind of water available in the oil fields.

H. J. Vandereb, Hartford Steam Boiler Inspection & Insurance Co., served notice on the diesel industry in his paper, "Diesel Engine Insurance." Mr. Vandereb spoke from an experience of about 7,000 engine-years, finding the diesel a poor risk and a "semi-permanent" machine. Diesel troubles were laid by him to (1) overloading, (2) faulty cooling systems, and (3) unsuitable fuel, principally. He saw no hope of establishing a graduated scale of risks with corresponding rates, but believed plants would necessarily continue to be rated as acceptable or unacceptable. The troubles could be easily minimized by more careful attention to loadings, water systems and fuel.

Discussion brought out that while there are between 30,000 and 40,000 diesels in use in the United States, this experience record has been established by some 400 units insured, a number that might easily be quite unrepresentative—in fact, undoubtedly so, in view of the high rate structure, which makes insurance uneconomical for the well-operated plant. Decided objection was taken to the branding of diesel machinery as "semi-permanent," one commentator stating that there have been scarcely any cases of diesels retired because of age.

Injection Systems

Carl Behn, United American Bosch Corp., defended the injection system for mechanical-injection diesels. Much trouble has been experienced, Mr. Behn admitted, when burning crude oils in engines which gave excellent performances on refined fuels. Whether this is due to erosion or corrosion, or both, makes little difference in view of the fact that either alone can ruin the best of injection parts.

Mr. Behn could not see much improvement coming from changes in the injection system alone. Use of stainless steels offers nothing because these cannot be hardened to a sufficient degree. Chromium plating cannot be deposited with enough uniformity. Nitrided steel parts are recommended, but, even so, only about 30% increased resistance to wear and corrosion should be expected.

The author's admonition was to look elsewhere for a cure for crude-fuel troubles. He felt that "all, or even nearly all, of the safeguards for injection equipment" had not been tried in a single case of an engine in difficulties because of crude oil. Direct cooling of the fuel nozzle offers the most improvement, not only in wear and corrosion but also in carbon deposition. Several means for accomplishing this were described for large engines and also for small units with much less cylinder head room available for nozzle-cooling arrangements.

Starting and stopping on light fuel oil should be a matter of routine when heavy fuel is used for operation. Fuel containing hydrogen-sulphide gas, especially with water, should not be heated to any higher temperature than that at which it will flow, and every possible chance should be given the H_2S to separate by providing settling tanks with proper vents. Centrifuging is recommended to remove the water which causes so much trouble in combination with H_2S.

Physical impurities such as sand, almost always present in crude oil, may be responsible for much of the trouble with that kind of fuel. Cloth filters with ample filtering area are best for this purpose if centrifuging is impracticable because of the location of the unit and the service.

Some discussors were inclined to be critical of manufacturers of injection equipment and engines for not carrying on more factory experimentation with crude oil as a fuel, but others believed field operations cannot be duplicated on the test floor. Several stressed the lack of suitable attention available to engines operating in remote districts in the oil fields as one stumbling block in attempting to meet the problem by bettering field conditions.

Compressed-Air Locomotives

Carl Bjornsson, of Clark Brothers, was not able to present his paper on "Compressed Air Transmission with Diesel Locomotives," but Harte Cooke, McIntosh & Seymour Corp. (a subsidiary of American Locomotive Co.) read it. The author described the various types of compressed-air systems in use in Europe, including the M.A.N., the Geiger, the external compression system, the Humbolt-Deutz, and the Götawerken. He proposed a transmission with superheated air, this consisting of a diesel plant driving 2-stage air compressors with oil-fired superheaters to heat the compressed air. This air is then used in locomotive cylinders in the same manner as steam. Regulation of the air compressed would be taken care of by a variable clearance volume in the low pressure compressor cylinder. The oil feed to the superheater would be thermostatically controlled to hold 1,100 deg. F.

Mr. Bjornsson predicted that such a compressed-air locomotive would have not only diesel economy but also more flexibility than steam because of the large volume of air available at slow speeds.

In commenting, Mr. Cooke stated that experience with compressed-air transmissions was meagre and therefore, any opinion about the cost of installation would be a guess. He felt that a closed system might be worth looking into because of the minimizing of the refrigerating effect with high back pressure.

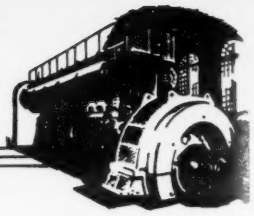
Questions were asked about hydraulic transmissions and Mr. Cooke reported that the New Haven Railroad had experimented with several in railcars and had given up the venture because of difficulties with leakage. European practice with hydraulic transmissions has been to use this for bringing the locomotive up to speed, with some mechanical locking device for steady running.

Round-Table Discussion

No formal papers were scheduled for the final session, but several round-table discussions were held. The first was on the subject of explosions in air compressors and air lines. It was brought out that explosion temperatures can be produced by the high compression ratios caused by low intake pressure due to altitude or to throttling the compressor intake. Intercooler explosions have been caused by exhaust gas corrosion where such gas was drawn into the compressor suction. Remedies which had been effective were the reduction of lubricating oil feed, the use of traps, and regulation of capacity by variable low-stage clearance instead of throttling.

The discussion on corrosion and fatigue of crankshafts and bearings inclined to the belief that all crankshaft failures today are due to misalignment. The lining up of crankshafts by paralleling coupling faces was declared bad practice. Overhung flywheels are not necessarily bad practice, but shafts for such construction should be designed to have the required cantilever strength.

The final topic for discussion was on the possibility of control of combustion pressure to secure smoother operation of mechanical-injection engines. The reduction of ignition lag and the proper control of injection rate were suggested. Ignition lag can be shortened by increasing the turbulence, raising the compression pressure, improving atomization, and the use of "hot spots." Control of injection rate is a matter of cam contour and nozzle design. The poorer fuels can often be made satisfactory by blending with relatively small amounts of good fuel.



DIESEL PLANT ACCESSORY

ACOUSTIC MATERIALS
(See also Isolation)
Armstrong Cork & Insulation Co., Lancaster, Pa.
Burgess Battery Co., Madison, Wis.
Johns-Manville, New York, N. Y.

AIR CLEANERS
(See Filters, Air)

ALARM SYSTEMS
Delco-Remy Corp., Anderson, Ind.
Federal Electric Co., Chicago, Ill.
Ill. Testing Labs., Inc., Chicago
Klaxon Co., Anderson, Ind.
Motometer Gauge & Equip. Corp., Toledo
Viking Instruments, Inc., N. Y. C.

ANALYZERS, EXHAUST GAS
Bacharach Ind. Inst. Co., Pittsburgh
Hays Corp., Michigan City, Ind.

BATTERIES, STORAGE
Electric Storage Battery Co., Phila.
Gould Storage Battery Co., Depew, N. Y.
Phila. Storage Battery Co., Phila.
Thomas A. Edison, Inc., West Orange, N. J.
U. S. L. Battery Corp., Niagara Falls, N. Y.

BEARINGS, ANTI-FRICTION
Aetna Ball Bearing Mfg. Co., Chicago, Ill.
Ahlberg Bearing Co., Chicago, Ill.
Bantam Ball Brg. Co., South Bend, Ind.
Fafnir Bearing Co., New Britain, Conn.
Hyatt Roller Brg. Co., Harrison, N. J.
New Departure Mfg. Co., Bristol, Conn.
Norma-Hoffman Bearings Corp., Stamford, Conn.
S K F Industries, Inc., Philadelphia
Shafer Bearing Corp., Chicago, Ill.
Timken Roller Bearing Co., Canton, O.

BEARINGS, BABBITT-LINED
American Bearing Corp., Indianapolis, Ind.
Beckett Bronze Co., Muncie, Ind.

BEARING METAL
W. D. Allen Mfg. Co., Chicago, Ill.
Baldwin Locomotive Co., Philadelphia
Bunting Brass & Bronze Co., Toledo
Eagle-Picher Lead Co., Cincinnati, O.
Magnolia Metal Co., Elizabeth, N. J.
Monarch Metal Co., Chicago, Ill.
E. L. Post & Co., N. Y. C.

BELTING, FLAT TRANSMISSION
Alexander Bros., Philadelphia, Pa.
W. D. Allen Mfg. Co., Chicago, Ill.
Chas. Bond Co., Philadelphia, Pa.
Chicago Belting Co., Chicago, Ill.
Chicago Rawhide Mfg. Co., Chicago
B. F. Goodrich Co., Akron, O.
Goodyear Tire & Rubber Co., Akron
Graton & Knight Co., Worcester, Mass.
E. F. Houghton & Co., Philadelphia
Manhattan Rubber Mfg. Div., Passaic, N. J.
New York Belting & Packing Co., N. Y. C.
Chas. A. Schieren Co., N. Y. C.
Thermoid Rubber Co., Trenton, N. J.
U. S. Rubber Co., N. Y. C.

BELTING, V-TYPE
Allis-Chalmers Mfg. Co., Milwaukee
Dayton Rubber Co., Dayton, Ohio
Fairbanks, Morse & Co., Chicago, Ill.
Gates Rubber Mfg. Co., Denver, Colo.
L. H. Gilmer Co., Philadelphia
B. F. Goodrich Co., Akron, Ohio
Goodyear Tire & Rubber Co., Akron, Ohio
Manhattan Rubber Mfg. Div., Passaic, N. J.
Worthington Pump & Machinery Corp., Harrison, N. J.

BLOWERS, SUPERCHARGING & SCAVENGING
Allen & Billmyre Co., Inc., So. Norwalk, Conn.
Allis-Chalmers Mfg. Co., Milwaukee
American Blower Co., Detroit, Mich.
Brown, Boverie & Co., Ltd., N. Y. C.
Elliott Co., Pittsburgh, Pa.
Roots-Connersville Blower Corp., Connersville, Ind.
B. F. Sturtevant Co., Hyde Park, Mass.

BOILERS, WASTE HEAT
Alco Products, Inc., New York, N. Y.
Babcock & Wilcox Co., N. Y. C.
Davis Engrg. Co., New York, N. Y.
Edge Moor Iron Co., Edge Moor, Del.
Foster Wheeler Corp., N. Y. C.
Union Iron Works, Erie, Pa.
Henry Vogt Machine Co., Louisville Ky.

CENTRIFUGES, OIL
De Laval Separator Co., N. Y. C.
De LaVergne Engine Co., Philadelphia
Goulds Pumps Inc., Seneca Falls, N. Y.
Wm. W. Nugent & Co., Chicago, Ill.
Sharples Specialty Co., Philadelphia
Westfalia Separator Co., Bloomfield, N. J.

CHAINS & CHAIN DRIVES
Baldwin-Duckworth Chain Corp., Springfield, Mass.
Boston Gear Works, N. Quincy, Mass.
Chain Belt Co., Milwaukee, Wis.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.
Ramsey Chain Co., Inc., Albany, N. Y.
Whitney Mfg. Co., Hartford, Conn.

CLUTCHES
W. E. Caldwell Co., Louisville, Ky.
Cutler-Hammer Mfg. Co., Milwaukee, Wis.
Dodge Mfg. Corp., Mishawaka, Ind.
F A B Mfg. Co., Oakland, Calif.
Fairbanks, Morse & Co., Chicago, Ill.
Hill Clutch Machine & Fdry. Co., Cleveland, Ohio
The Hilliard Corp., Elmira, N. Y.
Kinney Mfg. Co., Boston, Mass.
Magnetic Mfg. Co., Milwaukee, Wis.
The Medart Co., St. Louis, Mo.
Reeves Pulley Co., Columbus, Ind.
Snow & Petrolli Mfg. Co., New Haven, Conn.
Twin-Disc Clutch Co., Racine, Wis.
John Waldron Corp., New Brunswick, N. J.

COCKS, CYLINDER
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Crane Co., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
W. H. Nicholson & Co., Wilkes-Barre, Pa.
Wm. Powell Co., Cincinnati, O.
Walworth Co., New York, N. Y.

COMPRESSORS, AIR
Allis-Chalmers Mfg. Co., Milwaukee
Bolinders Co. Inc., New York, N. Y.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., N. Y. C.
Curtis Pneumatic Machry. Co., St. Louis
Elliott Co., Pittsburgh, Pa.
Fairbanks, Morse & Co., Chicago
Fuller Co., Catasauqua, Pa.
Gardner-Denver Co., Quincy, Ill.
Hill Diesel Engine Co., Lansing, Mich.
Ingersoll-Rand Co., New York, N. Y.
Nash Engrg. Co., So. Norwalk, Conn.
Nordberg Mfg. Co., Milwaukee, Wis.
Nova Engine Co., Lansing, Mich.
Pa. Pump & Compressor Co., Easton, Pa.
Quincy Compressor Co., Quincy, Ill.
Sullivan Mach. Co., Chicago, Ill.
Worthington Pump & Machinery Corp., Harrison, N. J.

COMPRESSOR VALVES
J. H. H. Voss, New York, N. Y.

CONNECTING RODS
Aluminum Co. of America, Pittsburgh
Atlas Drop Forge Co., Lansing, Mich.
Bethlehem Steel Co., Bethlehem, Pa.
Erie Forge Co., Erie, Pa.
Heppenstall Co., Pittsburgh, Pa.
Mesta Machine Co., Pittsburgh, Pa.
National Forge & Ordnance Co., Irvine, Warren Co., Pa.

CONTROL, VOLTAGE
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady, N. Y.
Leeds & Northrup Co., Philadelphia
R. E. S. Swan & Co., Hanover, Pa.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

CONTROL, AUTOMATIC
Automatic Diesel Electric Inc. N.Y.C.
Bromfield Mfg. Co., Inc., Boston
C. F. Strong, Chicago Pneumatic Tool Co., New York, N. Y.

CONTROLLERS, TEMPERATURE
Bailey Meter Co., Cleveland, Ohio
The Bristol Co., Waterbury, Conn.
Leeds & Northrup Co., Philadelphia
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Sarco Co., New York, N. Y.
Taylor Instrument Cos., Rochester, N. Y.
Thomas A. Edison, Inc., West Orange, N. J.

COOLERS, OIL
Alco Products Co., New York, N. Y.
Andale Co., Philadelphia, Pa.
Coen Co., Los Angeles, Calif.
Davis Engrg. Co., New York, N. Y.
Foster Wheeler Corp., N. Y. C.
Griscom-Russell Co., N. Y. C.
Gross Mechanical Lab., Baltimore, Md.
Harrison Radiator Co., Lockport, N. Y.
Heat Exchanger Co., Grove City, Pa.
Ingersoll-Rand Co., New York, N. Y.
Rome-Turney Radiator Co., Rome, N. Y.
Schutte & Koerting Co., Phila.
Henry Vogt Machine Co., Louisville
Young Radiator Co., Racine, Wis.
Zenith-Detroit Corp., Detroit, Mich.

COOLING TOWERS
Alco Products Co., New York, N. Y.
Binks Mfg. Co., Chicago, Ill.
Edwin Burhorn Co., Hoboken, N. J.
Cooling Tower Co., Inc., N. Y. C.
Fluor Corp., Los Angeles, Calif.
Foster Wheeler Corp., New York, N. Y.
Harry Cooling & Equip. Co., Phila.
Marley Co., Kansas City, Mo.
Schubert-Christy Co., Affton, Mo.
James M. Seymour, Inc., East Orange, N. J.
C. H. Wheeler Mfg. Co., Phila.

COUPLINGS
Ajax Flexible Coupling Co., Westfield, N. Y.
Allis-Chalmers Mfg. Co., Milwaukee
American Flexible Coupling Co., Erie, Pa.
Bartlett Hayward Co., Baltimore
Boston Gear Works, Inc., N. Quincy, Mass.
Diamond Chain Co., Indianapolis
F A B Mfg. Co., Oakland, Calif.
Falk Co., Milwaukee, Wis.
Farrell-Birmingham Corp., Ansonia, Conn.
General Electric Co., Schenectady, N. Y.
The Hilliard Corp., Elmira, N. Y.
D. O. James Mfg. Co., Chicago, Ill.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.
Poole Foundry & Machine Co., Baltimore, Md.
Thomas Flexible Coupling Co., Warren, Pa.
John Waldron Corp., New Brunswick, N. J.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

CRANKSHAFTS
Bethlehem Steel Co., Bethlehem, Pa.
Camden Forge Co., Camden, N. J.
Erie Forge Co., Erie, Pa.
Midvale Co., Philadelphia
National Forge & Ordnance Co., Irvine Co., Pa.
Titusville Forge Co., Titusville, Pa.
Washington Iron Works, Sherman, Tex. (Repair)

CYLINDER HONING TOOLS
Barnes Drill Co., Rockford, Ill.
Micromatic Hone Corp., Detroit

DRIVES
(See also Reducers, Gearing, etc.)
Boston Gear Works, Inc., N. Quincy, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Fairbanks, Morse & Co., Chicago, Ill.
The Medart Co., St. Louis, Mo.
Morse Chain Co., Ithaca, N. Y.
Reeves Pulley Co., Columbus, Ind.
Worthington Pump & Machinery Corp., Harrison, N. J.

EXPANSION JOINTS
American District Steam Co., No. Tonawanda, N. Y.
E. B. Badger & Sons Co., Boston
Philip Carey Co., Lockland, Cincinnati
Croll Reynolds Engrg. Co., New York
Direct Separator Co., Syracuse, N. Y.
Goodyear Tire & Rubber Co., Akron
Penna. Metallic Tubing Co., Phila.
Yarnall-Waring Co., Philadelphia

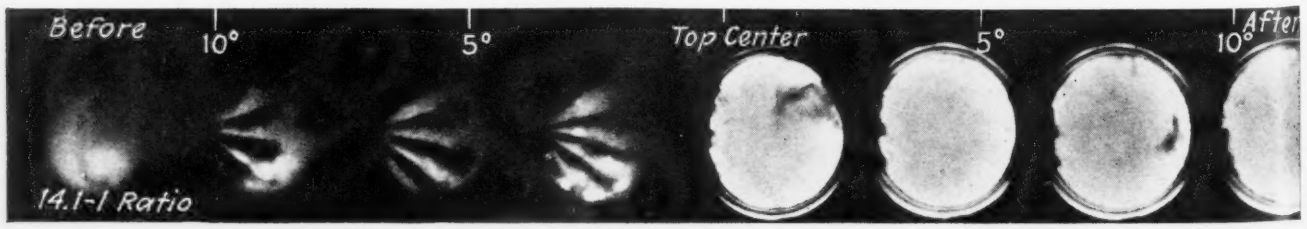
FILTERS, AIR
Air-Maze Corp., Cleveland, O.
American Air Filter Co., Louisville
Burgess Battery Co., Madison, Wis.
Centrifix Corp., Cleveland, Ohio
Coppus Engrg. Co., Worcester, Mass.
Independent Air Filter Co., Inc., Chicago, Ill.
Stayniew Filter Corp., Rochester, N. Y.
J. E. Swendemann, Inc., Boston
United Air Cleaner Corp., Chicago
Vortex Mfg. Co., Claremont, Calif.

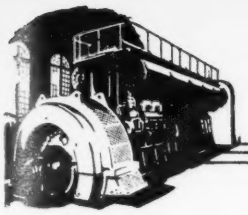
FILTERS, OIL
Burt Mfg. Co., Akron, O.
Cuno Engrg. Corp., Meriden, Conn.
DeLaval Separator Co., N. Y. C.
Diesel Filter Co., Astoria, Ore.
Michiana Products Corp., Michigan City, Ind.
Motor Improvements, Inc., Newark, N. J.
Wm. W. Nugent & Co., Inc., Chicago, Ill.
Schutte & Koerting Co., Phila.
Zenith-Detroit Corp., Detroit, Mich.

FILTERS, WATER
Cochrane Corp., Philadelphia, Pa.
Elgin Softener Corp., Elgin, Ill.
Grover Tank & Mfg. Corp., East Chicago, Ind.
International Filter Co., Chicago
Loomis-Manning Filter Co., Phila.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago

FREQUENCY CONTROL
General Electric Co., Schenectady, N. Y.
Leeds & Northrup Co., Philadelphia

This strip of super-speed photos and those on the two pages following show the effect of air-fuel ratio on fuel spray and flame formation in a diesel. Speed is 1,500 r.p.m., jacket temperature 150 deg. F.





AND SUPPLY MANUFACTURERS

Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Woodward Governor Co., Rockford, Ill.

GAGES, PRESSURE
Ashton Valve Co., Cambridge, Mass.
Bristol Co., Waterbury, Conn.
Consolidated Ashcroft-Hancock Co., Inc., Bridgeport, Conn.
Esterline-Angus Co., Indianapolis
Foxboro Co., Foxboro, Mass.
Hays Corp., Michigan City, Ind.
Motometer Gauge & Equip. Co., Toledo
Pelling Instrument Co., Brooklyn
United States Gauge Co., N. Y. C.
Viking Instruments, Inc., N. Y. C.

GAGES & METERS, RECORDING
Bailey Meter Co., Cleveland, O.
Bristol Co., Waterbury, Conn.
Brown Inst. Co., Philadelphia
Consolidated Ashcroft-Hancock Co., Bridgeport, Conn.
Defender Automatic Regulator Co., St. Louis, Mo.
Foxboro Co., Foxboro, Mass.
Leeds & Northrup Co., Philadelphia
Jas. P. Marsh & Co., Chicago
Motometer Gauge & Equip. Corp., Toledo
Republic Flow Meters Co., Chicago
Taylor Instrument Cos., Rochester, N. Y.
U. S. Gauge Co., New York, N. Y.

GAGES, STRAIN OR CRANKSHAFT
Hartford Steam Boiler Inspection & Insurance Co., Hartford, Conn.
L. S. Starrett Co., Athol, Mass.

GAGES, TANK
Detroit Lubricator Co., Detroit, Mich.
Foxboro Co., Foxboro, Mass.
King-Seeley Co., Ann Arbor, Mich.
Leeds & Northrup Co., Philadelphia
Liquidometer Corp., L. I. City, N. Y.
Lunkenheimer Co., Cincinnati, O.
Marshalltown Gage Co., Marshalltown, Ia.
Pneumercator Co., Inc., New York
Walworth Co., New York, N. Y.

GASKETS & PACKINGS
Acme Mfg. & Gasket Co., Phila.
Akron Metallic Gasket Co., Akron, O.
Allpax Co., Inc., Mamaroneck, N. Y.
Anchor Packing Co., Philadelphia
Belmont Packing & Rubber Co., Philadelphia, Pa.
Boston Woven Hose & Mfg. Co., Cambridge, Mass.
A. W. Chesterton Co., Boston, Mass.
Chicago Wilcox Mfg. Co., Chicago
Conneaut Packing Co., Conneaut, O.
C. Lee Cook Mfg. Co., Louisville, Ky.
Cooper Mfg. Co., Marshalltown, Ia.
Crandall Packing Co., Palmyra, N. Y.
Crane Packing Co., Chicago, Ill.
Cup-Lok Packing Co., Philadelphia
Durabla Mfg. Co., New York, N. Y.
Edge Packing & Rubber Co., N. Y. C.
Eureka Packing Co., Brooklyn, N. Y.
Federal Metallic Packing Co., Wakefield, Mass.
Ferodo & Asbestos, Inc., New Brunswick, N. J.
Flexitallic Gasket Co., Camden, N. J.
France Packing Co., Tacony, Pa.
Garlock Packing Co., Palmyra, N. Y.
Goetze Gasket & Packing Co., N. Y. C.
Goodall Rubber Co., New York, N. Y.
Greene, Tweed & Co., N. Y. C.
Home Rubber Co., Trenton, N. J.
Huhn Packing Co., New York, N. Y.
Johns-Manville, New York, N. Y.
Linear Packing & Rubber Co., Phila.
Mubbs Hydraulic Pkg. Co., Chicago
Manhattan Rubber Mfg. Div., Passaic, N. J.
Metallo Gasket Co., New Brunswick, N. J.
Packing Engrg. Corp., Cranford, N. J.
Pioneer Rubber Mills, San Francisco, Calif.
Quaker City Rubber Co., Philadelphia
Republic Rubber Co., Youngstown, O.
Ryan Metallic Packing Co., Chicago
U. S. Rubber Co., New York, N. Y.
Vellumoid Co., Worcester, Mass.
Victor Mfg. & Gasket Co., Chicago
Jas. Walker & Co., New York, N. Y.
Watson-Stillman Co., Roselle, N. J.

GEARING
Boston Gear Works, Inc., N. Quincy, Mass.
Cleveland Worm & Gear Co., Cleveland
DeLaval Steam Turbine Co., Trenton, N. J.
Falk Corp., Milwaukee, Wis.
Farrell-Birmingham Co., Ansonia, Conn.
Gears & Forgings, Inc., Cleveland.
D. O. James Mfg. Co., Chicago, Ill.
W. A. Jones Fdry. & Machine Co., Chicago, Ill.
Link-Belt Co., Chicago, Ill.
Philadelphia Gear Works, Phila.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

GENERATORS & EXCITERS
Allis-Chalmers Mfg. Co., Milwaukee
Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.
Delco-Remy Corp., Anderson, Ind.
Diehl Mfg. Co., Elizabethport, N. J.
Elliott Co., Pittsburgh, Pa.
Fairbanks, Morse & Co., Chicago, Ill.
Fidelity Elec. Co., Lancaster, Pa.
General Electric Co., Schenectady, N. Y.
Ideal Elec. & Mfg. Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

GOVERNORS
Gardner-Denver Co., Quincy, Ill.
Massey Machine Co., Watertown, N. Y.
Pickering Governor Co., Portland, Conn.
Pierce Governor Co., Anderson, Ind.
United American Bosch Corp., Springfield, Mass.
Woodward Governor Co., Rockford, Ill.

GREASE
(See Oil—Fuel and Lubricating)

HEAT EXCHANGERS
Alco Products, Inc., New York, N. Y.
Andale Co., Philadelphia
Cooling Tower Co., Inc., N. Y. C.
Croll-Reynolds Engrg. Co., N. Y. C.
Davis Engrg. Co., New York, N. Y.
Edge Moor Iron Co., Edge Moor, Del.
Elgin Softener Corp., Elgin, Ill.
Foster Wheeler Corp., N. Y. C.
Griscom-Russell Co., New York, N. Y.
Harrison Radiator Corp., Lockport, N. Y.
Morton Mfg. Co., Muskegon, Mich.
Schubert-Christy Corp., Afton, Mo.
Schutte & Koerting Co., Phila.
Henry Vogt Mach. Co., Louisville
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
C. H. Wheeler Mfg. Co., Phila.
Young Radiator Co., Racine, Wis.

HEATERS, OIL
(See Coolers, Oil)

HOSE, FLEXIBLE METAL
American Metal Hose Co., Waterbury, Conn.
Atlantic Metal Hose Co., Inc., N. Y. C.
Chicago Tubing & Braiding Co., Chicago
Federal Metal Hose Corp., Buffalo.
Pa. Flexible Metallic Tubing Co., Phila.
United Metal Hose Co., Inc., N. Y. C.
Weatherhead Co., Cleveland, O.

HOSE, OIL-PROOF RUBBER
B. F. Goodrich Co., Akron, O.
Goodyear Tire & Rubber Co., Akron.
Manhattan Rubber Mfg. Div., Passaic, N. J.
U. S. Rubber Co., New York, N. Y.

INDICATORS, SPEED, ETC.
Amthor Testing Inst. Co., Brooklyn
Bacharach Indus. Inst. Co., Pittsburgh, Pa.
James G. Biddle Co., Philadelphia.
Bristol Co., Waterbury, Conn.
Cutler-Hammer, Inc., Milwaukee
Leeds & Northrup Co., Philadelphia
George Scherr Co., Inc., N. Y. C.
C. J. Tagliabue Mfg. Co., Brooklyn
Trill Indicator Co., Corry, Pa.
O. Zernickow Co., New York, N. Y.

INDICATORS, SIGHT FLOW
Wm. W. Nugent & Co., Inc., Chicago

INDICATORS, FREQUENCY
Leeds & Northrup Co., Philadelphia

INJECTION SYSTEMS, FUEL
Ex-Cell-O Aircraft & Tool Corp., Detroit
Murphy Diesel Co., Ltd., Milwaukee
Nicholas Fodor, New York, N. Y.
United American Bosch Corp., Springfield, Mass.
Viking Pump Co., Cedar Falls, Ia.

INSTRUMENT PANELS, ENGINE
Viking Instruments, Inc., N. Y. C.

INSTRUMENTS, TESTING
General Electric Co., Schenectady.
Leeds & Northrup Co., Philadelphia
C. J. Tagliabue Mfg. Co., Brooklyn
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Weston Elec. Inst. Co., Newark, N. J.

INSULATING MATERIALS
Armstrong Cork Mfg. Co., Lancaster, Pa.
Philip Carey Co., Lockland, Cincinnati, O.
Eagle Picher Lead Co., Joplin, Mo.
Johns-Manville Corp., N. Y. C.
Keasby & Mattison Co., Ambler, Pa.

ISOLATION, CORK, RUBBER
Armstrong Cork Co., Lancaster, Pa.
Keldur Corp., New York, N. Y.
Korfund Co., Long Island City, N. Y.
Manhattan Rubber Mfg. Div., Passaic, N. J.
Mundet Corp., New York, N. Y.
U. S. Gypsum Co., Chicago, Ill.
Vibration Isolator Corp., N. Y. C. (Spring).

JOINTS, FLEXIBLE
Moran Flexible Joint Co., Louisville
Natl. Valve & Equip. Co., Pittsburgh
Pittsburgh Piping & Equip. Co., Pittsburgh, Pa.
Pittsburgh Valve Fdry. & Constr. Co., Pittsburgh, Pa.
United Metal Hose Co., Inc., N.Y.C.

LINERS, CYLINDER
Farrell-Birmingham Co., Ansonia, Conn.
Hunt-Spiller Mfg. Co., So. Boston
Sun Shipbuilding & Drydock Co., Chester, Pa.

LUBRICATORS
Alemite Mfg. Corp., Chicago, Ill.
S. F. Bowser Co., Fort Wayne, Ind.
Crane Co., Chicago, Ill. (Oil cups)
Gits Bros. Mfg. Co., Chicago, Ill.
Greene, Tweed Co., New York, N. Y.
Ideal Lubricator Co., Philadelphia
J. E. Lonergan Co., Philadelphia, Pa. (Oil cups)
Lunkenheimer Co., Cincinnati (Oil Cups)
McCord Lubricator Co., Detroit.
Madison Kipp Lubricator Co., Madison, Wis.
Manzel Bros. Co., Buffalo, N. Y.
Oil & Waste Saving Machine Co., Philadelphia, Pa.
Penberthy Injector Co., Detroit (Oil Cups).
Quimby Pump Co., Newark, N. J.

MANIFOLDS, SILENCING
Burgess Battery Co., Madison, Wis.

MANOMETERS
American Blower Corp., Detroit
Amer. Inst. Co., Washington, D. C.
Bacharach Indus. Inst. Co., Pittsburgh, Pa.
Bailey Meter Co., Cleveland, O.
J. A. Campbell Co., Long Beach, Cal.
Defender Automatic Regulator Co., St. Louis, Mo.
Ellison Draft Gage Co., Chicago, Ill.
Meriam Co., Cleveland, Ohio
Republic Flow Meters Co., Chicago
Schutte & Koerting Co., Phila.
Simplex Valve & Meter Co., Phila.

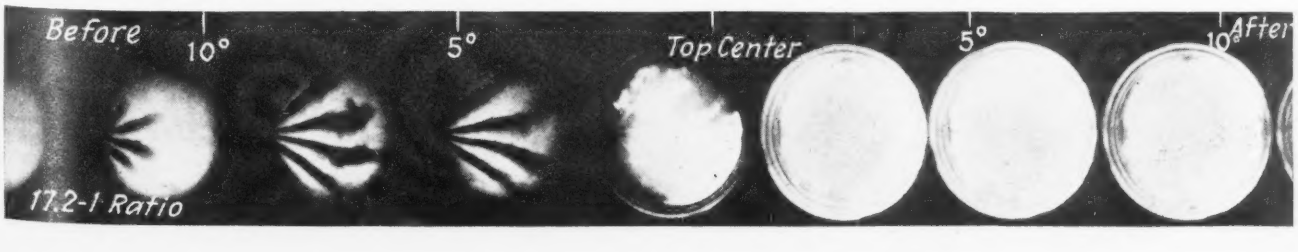
METERS, WATER OR OIL
Brown Inst. Co., Philadelphia, Pa.
Buffalo Meter Co., Buffalo, N. Y.
Builders Iron Foundry, Providence.
Foxboro Co., Foxboro, Mass.
Neytune Meter Co., New York, N. Y.
Pittsburgh Equitable Meter Co., Pittsburgh, Pa.
Republic Flow Meters Co., Chicago
Simplex Valve & Meter Co., Phila.
Worthington Pump & Machry. Corp., Harrison, N. J.
Yarnall-Waring Co., Philadelphia

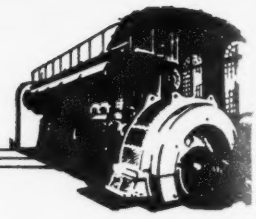
METERS, TEMPERATURE
Automatic Temp. Control Co., Phila.
Bailey Meter Co., Cleveland, O.
Bristol Co., Waterbury, Conn.
Brown Instrument Co., Philadelphia
Builders Iron Fdry., Providence, R. I.
A. W. Cash Co., Decatur, Ill.
Esterline-Angus Co., Indianapolis
Foxboro Co., Foxboro, Mass.
Illinois Testing Labs., Chicago, Ill.
Leeds & Northrup Co., Philadelphia
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Motometer Gauge & Equip. Co., Toledo
National Meter Co., Brooklyn, N. Y.
Neptune Meter Co., New York, N. Y.
Taylor Instrument Cos., Rochester, N. Y.
Thwing Instrument Co., Philadelphia
Viscosity Engrg. Co., New York
Weston Elec. Inst. Co., Newark, N. J.

MUFFLERS, INTAKE & EXHAUST
Burgess Battery Co., Madison, Wis.
Engrg. Spec. Co., Inc., N. Y. C.
Foster Wheeler Corp., N. Y. C.
Maxim Silencer Co., Hartford, Conn.

OIL, FUEL & LUBRICATING
Acheson-Oildag Co., Port Huron, Mich. (Colloidal Graphite).
Asiatic Petroleum Co., N. Y. C.
Borne-Scrymser Co., N. Y. C.
Cities Service Co., N. Y. C.
Continental Oil Co., Ponca City, Okla.
Adam Cook's Sons Co., Linden, N. J.
Deep Rock Oil Corp., Chicago, Ill.
Gulf Refining Co., Pittsburgh, Pa.
E. F. Houghton & Co., Philadelphia
Keystone Lubricating Co., Phila.
The Lubal Co., Columbus, Ohio (Lubricating concentrate in fuel)
Lubriplate Corp., New York, N. Y.
Marathon Oil Co., P. O. Box 2064, Tulsa, Okla.
Nassau Labs., New York, N. Y. (Colloidal graphite)
National Refining Co., Cleveland, O.
Paragon Oil Co., New York, N. Y.
Pennzoil Co., Oil City, Pa.
Pure Oil Co., Chicago, Ill.
Pyroil Co., La Crosse, Wis. (Concentrate)
Shell Petroleum Corp., St. Louis, Mo.
Sinclair Refining Co., N. Y. C.
Socony-Vacuum Corp., N. Y. C.
Standard Oil Co., (Ind.), Chicago
Sun Oil Co., Philadelphia, Pa.
The Texas Company, N. Y. C.

These photographs were taken at a rate of 2,500 frames per second at Langley Field, Va., by the National Advisory Committee for Aeronautics. This is the ideal air-fuel ratio 17.2-1





Tide Water Oil Sales Corp., N. Y. C.
Viscosity Oil Co., Chicago, Ill.
Waverly Oil Works, Pittsburgh, Pa.

OIL PURIFICATION SYSTEMS
Alco Products, Inc., N. Y. C.
DeLaval Separator Co., N. Y. C.
De La Vergne Eng. Co., Philadelphia
Goulds Pumps, Inc., Seneca Falls, N. Y.
Wm. W. Nugent & Co., Chicago, Ill.
Sharples Specialty Co., Philadelphia

OIL RECLAMATION SYSTEMS
Hilliard Corp., Elmira, N. Y.
Skinner Motors, Inc., Detroit, Mich.
Youngstown Steel Car Corp., Niles, O.

PACKING
(See Gaskets & Packing)

PIPE FITTINGS AND PIPE
Bonney Forge & Tool Works, Reading, Pa.
A. M. Byers Co., Pittsburgh, Pa.
Chase Brass & Copper Co., Waterbury, Conn.
Crane Co., Chicago, Ill.
Grinnell Co., Providence, R. I.
Homestead Valve & Mfg. Co., Coraopolis, Pa.
Jefferson Union Co., New York, N. Y.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
E. F. Keating Pipe Bending & Supply Co., New York, N. Y.
Lunkenheimer Co., Cincinnati, O.
Midwest Piping & Supply Co., St. Louis, Mo.
National Valve & Mfg .Co., Pittsburgh, Pa.
Wm. W. Nugent & Co., Chicago, Ill.
Pennsylvania Forge Co., Philadelphia
Pittsburgh Piping & Equip. Co., Pittsburgh, Pa.
Pittsburgh Steel Co., Pittsburgh
Reading Iron Co., Reading, Pa.
Republic Steel Corp., Youngstown.
Rockwood Sprinkler Co., Worcester, Mass.
John Simmons Co., Long Island City.
Stockham Pipe & Fitting Co., Birmingham, Ala.
Taylor Forge & Pipe Works, Chicago
Tube-Turns, Inc., Louisville, Ky.
United Metal Hose Co., N. Y. C.
Henry Vogt Machine Co., Louisville
Watson-Stillman Co., Roselle, N. J.
Weatherhead Co., Cleveland

PISTONS
Arrowhead Steel Products Co., Minneapolis, Minn.
Delco-Remy Corp., Anderson, Ind.
DeLuxe Products Co., LaPorte, Ind.

PISTON RINGS
American Hammered Piston Ring Co., Baltimore, Md.
C. Lee Cook Mfg. Co., Louisville, Ky.
Double Seal Ring Co., Fort Worth
Sealed Power Corp., Muskegon, Mich.
Skinner Chuck Co., New Britain, Conn.
A. P. Ward Inc., Cincinnati, O.

PUMPS
Fairbanks, Morse & Co., Chicago, Ill.
Foster Wheeler Corp., N. Y. C.
Gardner-Denver Co., Quincy, Ill.
Goulds Pumps, Inc.,Seneca Falls,N.Y.
Ingersoll-Rand Co., New York, N. Y.
Kinney Mfg. Co., Boston, Mass.
Manzel Bros. Co., Buffalo, N. Y.
Wm. W. Nugent & Co., Chicago
Quincy Compressor Co., Quincy, Ill.
Viking Pump Co., Cedar Falls, Ia.
Warren Steam Pump Co., Warren, Mass.
Westco Pump Corp., Davenport, Ia.
Worthington Pump & Machinery Corp., Harrison, N. J.

PYROMETERS
Bailey Meter Co., Cleveland, O.
Bristol Co., Waterbury, Conn.
Brown Inst. Co., Philadelphia, Pa.
Illinois Testing Labs., Inc., Chicago
Leeds & Northrup Co., Philadelphia
Mishawaka Indus. Inst. Mfg. Lab., Mishawaka, Ind.
C. J. Tagliabue Mfg. Co., Brooklyn
Taylor Instrument Cos., Rochester, N. Y.

RADIATORS
American Radiator Co., N. Y. C.
Perfex Corp., Milwaukee, Wis.
Rome-Turney Radiator Co., Rome, N. Y.
Young Radiator Co., Racine, Wis.

RECEIVERS, AIR
Ingersoll-Rand Co., New York, N. Y.

RECORDERS
Bailey Meter Co., Cleveland, O.
Bristol Co., Waterbury, Conn.
Leeds & Northrup Co., Philadelphia
Motometer Gauge & Equip. Corp., Toledo

REGULATORS, CURRENT & VOLTAGE
Bromfield Mfg. Co., Inc., Boston.
Delco-Remy Corp., Anderson, Ind.
General Electric Co., Schenectady.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

REPAIRS
Washington Iron Works, Sherman, Tex.

SAFETY CONTROL, ENGINE
Viking Instruments, Inc., N. Y. C.

SCALE RETARDERS, JACKET WATER
Artic Chemical & Combustion Engrg. Corp., Brooklyn, N. Y.
W. H. & L. D. Betz, Philadelphia, Pa.
Dearborn Chemical Co., Chicago, Ill.
Feedwaters, Inc., New York, N. Y.
National Aluminate Co., Chicago, Ill.

SCHOOLS, DIESEL ENGINEERING
L. L. Adcox Trade School, 237 N.E. Broadway, Portland, Ore.
Diesel Power Engrg. Schools, 3320 20th St., San Francisco, Calif.
Hemphill Diesel Engrg. Schools, Inc. 3128 Queens Blvd., L. I. City, N. Y.
New York Diesel Institution, Inc., 737 Broadway, Albany, N. Y.
Dr. O. F. Schoeck School of Diesel Engrg., Alton, Ill.
United States Diesel School, 1105 Commonwealth Ave., Boston, Mass.

SEPARATOR, SEDIMENT
Cochrane Corp., Philadelphia, Pa.
Crane Co., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, Ohio
Swartwout Co., Cleveland, Ohio

SHIMS
Keystone Casket Mfg. Co., Phila.
Laminated Shim Co., L. I. City, N.Y.
Victor Mfg. & Gasket Co., Chicago

SILENCERS
Burgess Battery Co., Madison, Wis.
Maxim Silencer Co., Hartford, Conn.
Staynew Filter Corp., Rochester

SOFTENERS, WATER
Cochrane Corp., Philadelphia, Pa.
Crane Co., Chicago, Ill.
Dearborn Chemical Co., Chicago
Elgin Softener Co., Elgin, Ill.
Graver Tank & Mfg. Co., East Chicago, Ind.
Hungerford & Terry, Inc., Clayton, N. J.
International Filter Co., Chicago
National Aluminate Corp., Chicago
Permutit Co., New York, N. Y.
Wm. B. Scaife & Sons, Oakmont, Pa.
Zeolite Chemical Co., N. Y. C.

SPEED REDUCERS & INCREASERS
(See also Gearing)
Boston Gear Works, Inc., N. Quincy, Mass.
Link-Belt Co., Chicago, Ill.
Philadelphia Gear Works, Phila.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

SPRAY PONDS
Binks Mfg. Co., Chicago, Ill.
Edwin Burhorn Co., Hoboken, N. J.
Cooling Tower Co., Inc., N. Y. C.
Marley Co., Kansas City, Mo.
Monarch Mfg. Works, Philadelphia
Yarnall-Waring Co., Philadelphia

STARTING UNITS
Bolinders Co., Inc., New York, N. Y.
Delco-Remy Corp., Anderson, Ind. (Elec.)
Fairbanks, Morse & Co., Chicago
Gardner-Denver Co., Quincy, Ill.
Hill Diesel Engine Co., Lansing, Mich.
Novo Engine Co., Lansing, Mich.
Quincy Compressor Co., Quincy, Ill.
Sullivan Machinery Co., Chicago
Worthington Pump & Machinery Corp., Harrison, N. J.

STEEL—GRATINGS, LADDERS
Blaw-Knox Co., Pittsburgh, Pa.
Hendricks Mfg. Co., Carbondale, Pa.
Illinois Steel Co., Chicago, Ill.
Irving Iron Wks Co., L. I. City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

STEEL, STRUCTURAL
Bethlehem Steel Co., Bethlehem, Pa.
Carnegie Steel Co., Pittsburgh, Pa.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Republic Steel Corp., Youngstown O.

STRAINERS
Andale Co., Philadelphia, Pa.
Blackburn-Smith Corp., Hoboken,N.J.
Edward Valve & Mfg. Co., East Chicago, Ind.
Elliott Co., Jeannette, Pa.
Jas. P. Marsh, Chicago, Ill.
Sarco Co., Inc., New York, N. Y.
Strong, Carlisle & Hammond Co., Cleveland, Ohio
Watts Regulator Co., Lawrence, Mass.

SWITCHES & SWITCHBOARDS
Allis-Chalmers Mfg. Co., Milwaukee
Bristol Co., Waterbury, Conn.
Bromfield Mfg. Co., Inc., Northern Ave., Boston, Mass.
Delco-Remy Corp., Anderson, Ind.
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

TACHOMETERS, ELECTRICAL
Viking Instruments, Inc., N. Y. C.
Weston Elec. Inst. Co., Newark

TANKS, STORAGE
Alberger Heater Co., Buffalo, N. Y.
S. F. Bowser Co., Fort Wayne, Ind.
W. E. Caldwell Co., Louisville, Ky.
Connery Const. Co., Philadelphia.
Graver Tank & Mfg. Co., East Chicago, Ind.
Hedges-Walsh-Weidner Co., Chattanooga, Tenn.
Littleford Bros., Cincinnati, O.
National Tube Co., Pittsburgh, Pa.
Wm. W. Nugent & Co., Inc., Chicago
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.
Wm. B. Scaife & Sons Co., Oakmont, Pa.
Sheet Metal & Conveyor Co., Chicago
William Bros. Boiler & Mfg. Co., Minneapolis, Minn.

THERMOCOUPLES
Bristol Co., Waterbury, Conn.
Brown Inst. Co., Philadelphia, Pa.
Leeds & Northrup Co., Philadelphia
C. J. Tagliabue Mfg. Co., Brooklyn.

THERMOMETERS
American Temp. Indicating Co., Toledo
Bailey Meter Co., Cleveland, Ohio
Bristol Co., Waterbury, Conn.
Brown Inst. Co., Philadelphia, Pa.
Consolidated Ashcroft-Hancock Co., Bridgeport, Conn.
Defender Automatic Regulator Co., St. Louis, Mo.
Charles Englehart Inc., Newark, N. J.
Foxboro Co., Foxboro, Mass.
King-Seeley Corp., Ann Arbor, Mich.
Leeds & Northrup Co., Philadelphia
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Motometer Gauge & Equip. Corp., Toledo
Precision Thermometer & Instrument Co., Philadelphia, Pa.
C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.
Taylor Inst. Cos., Rochester, N. Y.
Uehling Inst. Co., Paterson, N. J.
Viking Inst. Co., New York, N. Y.

TRANSMISSIONS
(See Gearing, Drives, Clutches)

VALVES
Ashton Valve Co., Cambridge, Mass.
Atlas Valve Co., Newark, N. J.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Collar Valve Corp., Berkeley, Calif.
Crane Co., Chicago, Ill.
Crosby Steam Gage & Valve Co., Boston, Mass.
Davis Regulator Co., Chicago, Ill.
Eddy Valve Co., Waterford, N. Y.
Edward Valve & Mfg. Co., East Chicago, Ind.
Everlasting Valve Co., Jersey City, N. J.
Homestead Valve & Mfg. Co., Coraopolis, Pa.
Hudson Brass Works, Brooklyn
Jenkins Bros., New York, N. Y.
Leslie Co., Lyndhurst, N. J.
J. E. Lonergan & Co., Philadelphia
Ludlow Valve Mfg. Co., Troy, N. Y.
Lunkenheimer Co., Cincinnati, Ohio
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Wm. W. Nugent & Co., Inc., Chicago
Pittsburgh Equitable Meter Co., Pittsburgh, Pa.
Pittsburgh Piping & Equip. Co., Pittsburgh, Pa.
Wm. Powell & Co., Cincinnati, O.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Ross Valve Co., Troy, N. Y.
John Simmons Co., Long Island City, N. Y.
Sweet & Doyle, Troy, N. Y.
United American Bosch Corp., Springfield, Mass. (Fuel spray)
Henry Vogt Machine Co., Louisville
J. H. N. Voss, Inc., N. Y. C.
Walworth Co., New York, N. Y.
Watson-Stillman Co., Roselle, N. J.
D. T. Williams Valve Co., Cincinnati, Ohio
Yarnall-Waring Co., Philadelphia

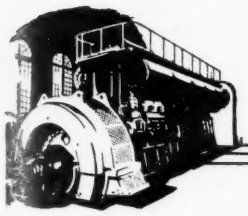
VALVE REGRINDING EQUIPMENT
Hutton & Jenks, Bancroft, Ia.
Leavitt Machine Co., Orange, Mass.

VIBROMETERS
James G. Biddle Co., Philadelphia
L. S. Starrett Co., Athol, Mass.
Westinghouse Elec. & Mfg. Co. East Pittsburgh, Pa.

CONSULTANTS
Oliver F. Allen, 117 Liberty, N.Y.C.
Helmer N. Anderson, Minneapolis.
Edward E. Ashley, 10 E. 40th St., New York, N. Y.
C. T. Baker, Atlanta, Ga.
Bemis Co., Chicago, Ill.
Julius G. Berger, Newark, N. J.
W. E. Boileau, Bath, N. Y.
Joseph Breslove, Syracuse, N. Y.
Bryan & Sigmon Engrg. Co., Inc., Loveland, Ohio
Burns & McDonnell Engrg. Co., Cincinnati, Ohio, Kansas City, Mo.
H. L. Cory Engrg. Co., Omaha, Neb.
Duro Co., Inc., 50 Church St., New York, N. Y.
W. A. Fuller Co., St. Louis, Mo.
Jos. Hecking, Philadelphia, Pa.
R. Husselman, Cleveland, Ohio
Kaiser, Muller & Davies, 101 Park Ave., New York, N. Y.
Edgar J. Kates, 415 Lexington Ave., New York, N. Y.
A. M. Lockett & Co., Ltd., Houston Tex.
Peter F. Loftus, Pittsburgh, Pa.
A. L. Mullergren, Kansas City, Mo.
W. B. Rollins & Co., 339 Railway Exchange Bldg., Kansas City, Mo.
Russell & Axon, St. Louis, Mo.
H. W. Stalnaker, Osceola, Ia.
F. N. Straus, Cleveland, Ohio
Wiley & Wilson, Richmond, Va.
Young & Stanley, Muscatine, Ia.

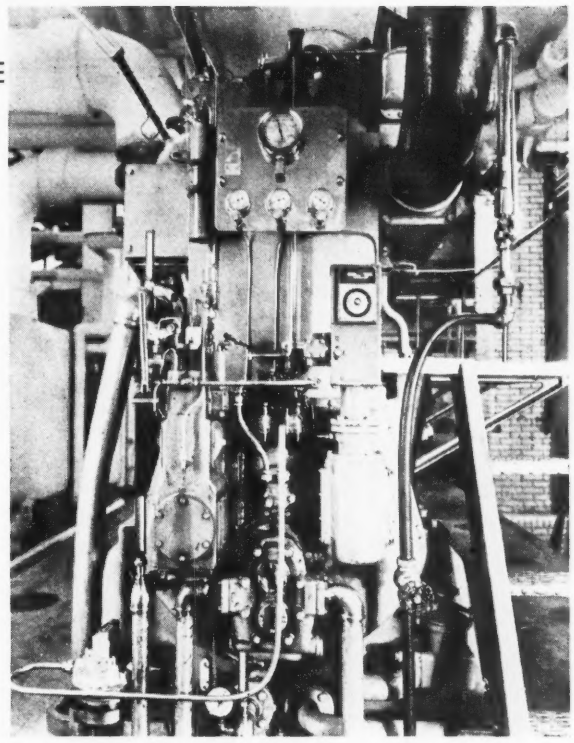
Listings are as complete and accurate as available information permits, but **Power** assumes no responsibility for errors or omissions.

Six-spray nozzle injects into a combustion chamber on a single-cylinder engine. No effort is made to create air turbulence. Interval between injection and autoignition about 10 deg.



SKYSCRAPER ADDS DIESEL

Singer Building, pioneer New York tower office building, improves heat balance of its steam plant with a diesel set on springs



Control end, showing gages and governor

"A PENNY saved is a penny earned"—in building power plants as well as in any other. Pennies are saved by improving heat balance while insuring flexibility, standby and breakdown service.

Office buildings have heavy load swings through the day, lighting peaks, and low load through the night and holidays. Steam load is good in winter, almost negligible in summer. Steam plants waste exhaust in summer and must always have standby and peak-load capacity—all costing money.

But when steam and diesel work together, the steam plant provides power to the extent of steam demand, the diesel carrying the rest of the load and peaks. The steam plant carries most of the load in winter, and the diesel (particularly if waste heat is used for heating service water) most, or all, in summer. One prime mover is standby for the other, and diesel flexibility and economy supplements byproduct steam economy.

The Singer Building, New York, first tower-type office building, has just completed America's first building installation of this kind. Singer also installed the first large building oil-fired boiler installation (June 1, 1920; paid for itself in 21 months), installed some of the first welded steel building piping and one of the first traction-type elevator sets. Constant increases in plant efficiency, constant pioneering to save power pennies—this is the story of the Singer Building, but more so of its chief engineer, Norman McLeod King.

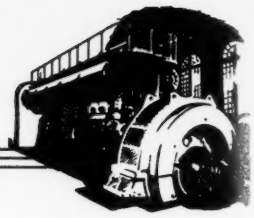
Built in 1896, the building was remodeled and a skyscraper tower added in 1906. The original power plant included 20,000 sq.ft. of water-tube boilers and five corliss engines. In 1903 a canny 27-year-old Scot named King had become assistant chief engineer. He'd been in America for 13 years, a marine engineer for 8 (he still holds Marine Engineer's First-Class certificates for both British and American vessels).

When the power plant burned out in 1909, King took the responsibility for building the new one, improving and modernizing it. Since then he has continually improved it, for fifteen years as chief engineer.

Mr. King's electrical load has been increasing, meaning more steam waste in summer, and his utility breakdown service cost him more than did his own current. Characteristically, his solution was a pioneering one—addition of a 350-kw. diesel-electric set. Taking out a spare boiler and large exhaust fan at the north end of the boiler room would provide room. His report to the building management suggested that a diesel consultant be called in to check his figures. Kaiser, Muller & Davies were retained; their study confirmed Mr. King's estimates. Specifications and plans included waste-heat recovery, proper vibration isolation, close control, up-to-date installation.

The purchased set comprised a 6-cyl., 525-hp. Winton diesel driving a 350-kw. d.c. Diehl generator.

Just under the boiler-room floor is the shallow mat or raft foundation of this part of the building. This meant that the diesel foundation had to be above floor level, with headroom for pulling pistons and liners limiting foundation height to 2 ft. The six photographs show the solution. Instead of the usual cork or occasional rubber isolation, this installation uses square-section coil springs at low stresses, in a special shallow vibration isolator designed by George D. Pogue. The springs rest below hydraulic pistons on sockets in the sub-foundation, the hydraulic cylinders being inverted over them and cast into the foundation. Hydraulic pressure lifts mat and diesel set and



supports them on the springs, then jackscrews in the cylinder heads are turned down to replace the hydraulic pressure. The mat then floats on twelve springs which allow $\frac{5}{16}$ in. vertical movement and $\frac{1}{4}$ in lateral.

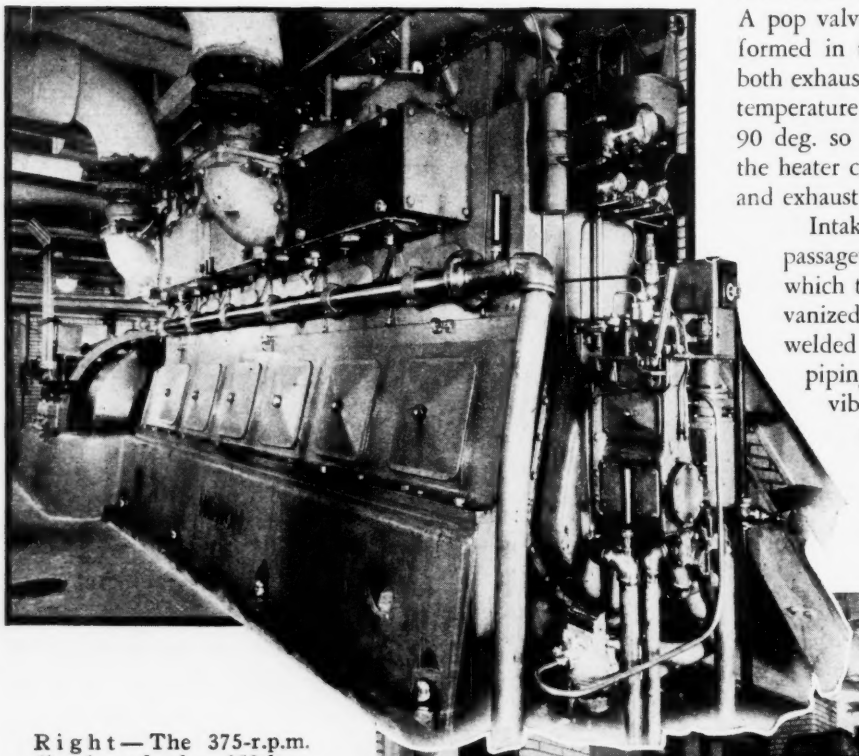
These springs are ground internally for matching and clearance. Accurately estimated and precision built, their transmissibility is 1/35. Engine vibration frequency is 18.75 cycles per sec., requiring about 1 in. compression. Each spring is designed to take half the load at its cross-section of the 84-ton load. Special rubber strips between floor and mat at each side damp oscillations during starting and stopping. At the operating end of the engine, a separate metal platform abuts the foundation to extend working space and cover the lubricating-oil cooler (Schutte & Koerting) pit.

A 150-g.p.m. Gould centrifugal pump circulates cooled jacket water through the lubricating-oil cooler and engine jackets. Part of the outlet water goes back through an expansion chamber to the suction side of the pump, the rest through a Schutte & Koerting heat exchanger (heating boiler makeup) to a 90-g.p.m. Binks indoor spray-type cooling tower. A 75-g.p.m. Gould pump forces water from the tower into the 150-g.p.m. pump discharge header at a rate necessary to give 130-deg. inlet water, control being by a Taylor thermostat-operated and a hand valve. Enough water is pumped through the engine to hold outlet temperature to 140 or 145 deg., this close control giving better operation and reducing maintenance.

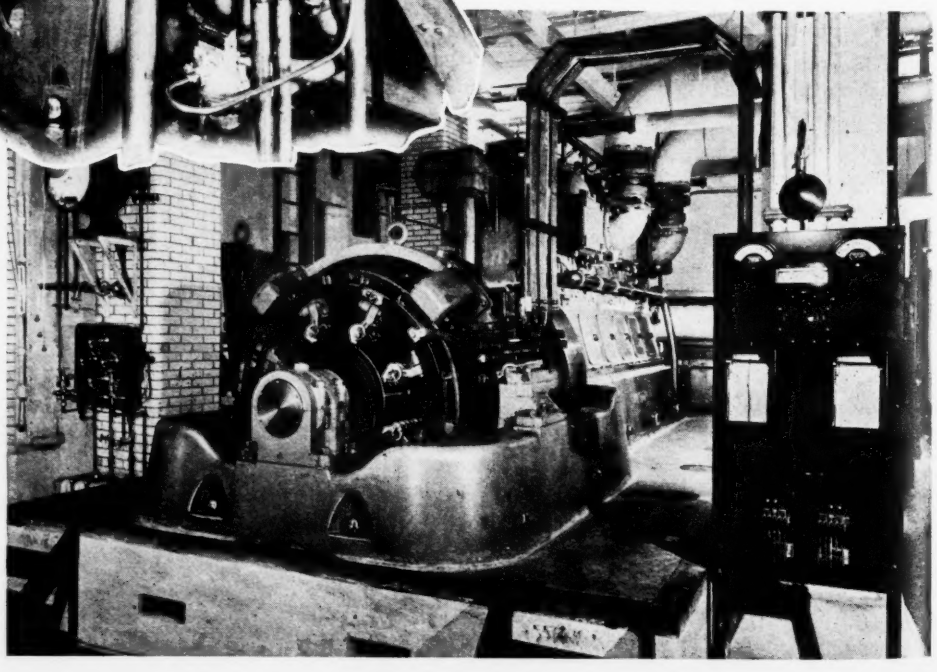
Air is forced through the tower by two fans driven by 3-hp. shunt motors. It leaves through a short duct to the large flue beside the boiler stack. Natural draft of the hot boiler-room air carries entrained moisture that passes tower drip baffles to the roof (14 stories above).

Welded double exhaust pipes lead from the engine exhaust manifold, one going through a Burgess silencer to the boiler flue, the other through a Foster-Wheeler exhaust-gas water heater which heats boiler feed (after it leaves the heat exchanger) to as high as 355 deg. F. A pop valve set at 190 lb. provides relief if steam is formed in the boiler due to reduced water flow. In both exhaust pipes, near the manifold, are special high-temperature butterfly valves with their shafts coupled at 90 deg. so that proportional volume passing through the heater can be controlled by handwheel. Hot water and exhaust pipes, heater and silencer are all insulated.

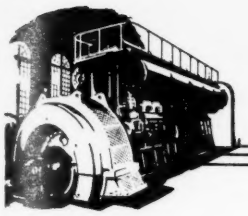
Intake air is drawn through an Annis filter in a passageway to a 3½x9-ft. sidewalk grille (through which this installation had to be brought!) a galvanized iron duct, 8-in. Burgess silencer and welded steel pipeline to the engine. All engine piping incorporates flexible sections to avoid vibration; all water and oil lines (except day-tank overflow) are brass.



Left—The 525-hp., 6-cyl., 14x16-in., 4-cycle solid injection Winton diesel just after installation



Right—The 375-r.p.m. diesel and the 350-kw., compound-wound interpole, 2-wire, 240-volt d.c. Diehl generator which it drives. Both have welded frames and are mounted together on a cast bed and common box-type reinforced concrete base 2 ft. thick carried on springs. Cooling tower, pumps and heaters are at left



DIESEL ENGINE DATA

Starting air is provided by $4\frac{1}{4}$x$2\frac{1}{4}$x$3\frac{1}{2}$-in. 2-stage Gardner-Denver air-cooled compressor V-belted to a 5-hp. motor. A pressure-controlled start-and-stop contact switch maintains 400 lb. per sq.in. pressure in two 8.3-cu.ft. tanks. Powered from the main switchboard, the set requires no standby.

Fuel oil (27 deg. Bé) is stored in a 7,800-gal. former boiler-fuel steel tank under the sidewalk. Oil passes through either of two Viking $\frac{1}{3}$-hp. transfer pumps controlled by mercoid float switch to Nugent filters and a 60-gal. day tank near the engine. It then flows by gravity through a meter and set of filters to the engine fuel pump.

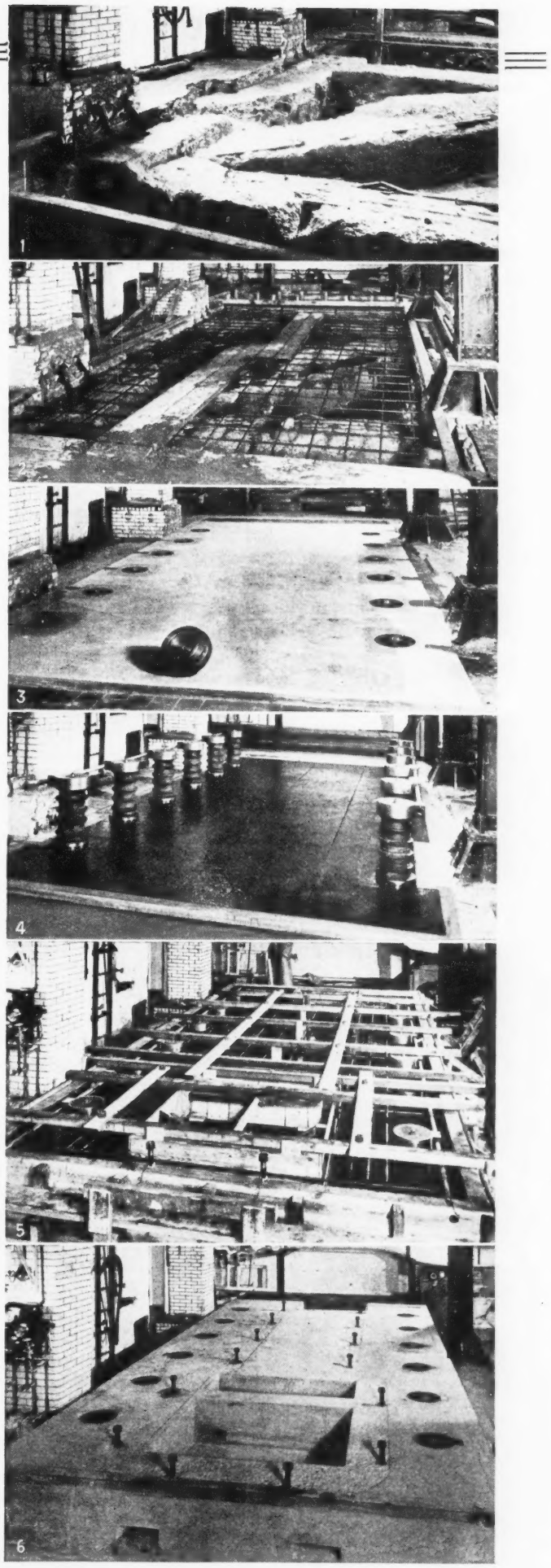
Lubricating oil is stored in two interconnected 150-gal. tanks, one for run, the other for storage. Both are piped to a 65-g.p.h. Sharples centrifuge (with integral 3-kw. heater to heat oil to 170 deg.) for either batch or bypass purifying. 150-deg. oil from the run tank is reduced to 135 in the 20-g.p.m. cooler, then passes through a duplex Purolator filter to the oil header. Pressure gages each side show filter condition.

Thermocouples in each exhaust outlet lead to a 6-pt. rotary switch and indicating pyrometer on the generator instrument board. A thermometer in the jacket-water outlet rings a bell over the board if temperature rises over 150 deg. If lubricating-oil pressure drops, a contact switch in the main engine oil header rings a bell.

Special large-diameter cable (to insure parallel operation) connects the diesel set and its control panel (formerly used for utility standby) on the main switchboard 150 ft. away. An audio-visual signal connects switchboard attendant and engine operator. A Woodward isochronous governor makes voltage variations negligible despite load surges.

Weston graphic ammeter and voltmeter, Bristol pyrometer, 2000-amp. 2-pole disconnecting switch and an emergency switch to trip the main breaker are all on the generator instrument board. Main cables come in to the upper studs of the 2,000-amp. switch. Copper busbars arch up and over from the lower studs to the terminal board on the generator field frame and provide flexibility to withstand starting oscillation.

White enamel and chromium trim will be used on the diesel to make it correspond with the rest of Mr. King's shipshape plant. His present plans are to generate about half of the annual 2,360,000 kw.-hr. with the diesel set. A 179-hr. test run the week of May 20 indicate about 12.4 kw.-hr. per gal. of fuel. Waste-heat recovery will save somewhat over $1,600 per year. Present operating personnel will handle the new engine. The installation is expected to pay out in four years.



Vibration Isolator—Building floor was removed to expose the mat or raft (1). On this a reinforced concrete sub-foundation (2) with 12 pintle-sockets (6 on a side) was built (3). Each pintle then was covered with a spiral spring and pintled hydraulic piston within a ribbed (to interlock with concrete) cylinder, interconnected (4), then cast into a reinforced concrete mat (5) that forms the foundation (6), shown here from the flywheel end. Cylinder heads can be removed for adjustment

TEST YOUR OWN BOILERS

By Walter H. Wood
Combustion Engineering Co., Inc.

Many plant operators have the mistaken notion that boiler tests must be elaborate to be of value. This is the first of a series of articles that will tell the operating engineer how to test his boilers with the simple equipment available in most plants

IT IS plainly out of the question for every engineer who may have to test a boiler to be fully trained under an experienced test engineer. Likewise, most industrial plants and some central stations haven't the elaborate testing equipment necessary to make tests as prescribed by the A.S.M.E. Boiler Test Code. Nevertheless, tests of more simple nature, when properly made, can be of great value in developing and maintaining economical operation.

But tests made by men who lack knowledge of the subject, using equipment that is not reliable, are often worse than useless—and are most likely to be misleading. To help the operating engineer, most of whom have a general knowledge of boiler testing, it is the purpose to tell here in a series of articles how to make simple boiler tests and to describe apparatus that can be depended upon to give reliable results and to point out methods to be followed that will avoid errors common to many tests.

Accuracy of results depends largely upon care and faithfulness of the observer, and it is much easier to make mistakes than is realized by those who are not familiar with testing. It is not sufficient for the engineer simply to follow rules—he must develop judgment which will enable him to know that the methods used and the results obtained are reliable within allowable limits.

What's the Test For?

The entire procedure of a boiler test, the amount and character of the data taken, all depend on the reason for making tests. For some purposes, a boiler test may be exceedingly simple, while for others a very large amount of data is necessary. Some of the reasons for making these tests are: 1. To determine whether or not the equipment is capable of fulfilling guarantees made by manufacturers. 2. To determine what efficiencies can be obtained when the boiler is operated under certain conditions, usually with reference to methods of firing, load conditions, regulation, etc. 3. To determine what capacity the boiler or any of its auxiliaries is capable of developing under operating conditions. 4. To study the economic value of different fuels used and available to the plant. 5. To study the effect of changes in design of furnace, bafflings, etc. 6. To determine how to obtain most economical performance. 7. To study over-all plant operation. Obviously, there may be many variations or combinations of these purposes, and the simplicity or elaborateness of the test depends upon whether one or a number of the above purposes are to be served by a single test.

Evaporative tests are most widely used to determine boiler efficiencies because of the greater accuracy possible. But often this is not practicable. It is evident, for example, that expensive equipment occupying large space would be required in weighing or measuring feed water used in large boiler units. Some of the large power stations are equipped to weigh feed water in excess of half a million pounds per hour, but they are exceptional. Many industrial plants are so limited as to space that water-measuring equipment cannot conveniently be installed or feed pumps in practice may be so arranged that it is impossible to make necessary connections for measuring or weighing. In such cases efficiency must be determined by heat balance methods.

Boiler Efficiency Is Simple

Boiler efficiency is the ratio of the heat added by the boiler in the steam output to the heat in the fuel supplied. For example, if 100,000 lb. of water at a temperature of 100 deg. are fed to a boiler and converted into saturated steam at 150 lb. gage, the heat output of the unit is found thus: In converting water at 100 deg. into steam at 150 lb. pressure, water is first heated by the products of combustion from 100 deg. up to the temperature corresponding to the boiling point at the 150-lb. pressure, and then evaporated into steam at that pressure. From steam tables it will be found that the heat content of 1 lb. of water (heat of liquid) at 150 lb. gage and 366 deg., is 338.5 B.t.u. The heat required to change this water at 150 lb. gage and 366 deg., into steam at that pressure (latent heat of vaporization) is 856.5 B.t.u. The sum of these quantities represents the total heat of steam at 150 lb. pressure, or 338.5 + 856.5 = 1,195.0 B.t.u. This "total heat" figure may be taken directly from the steam tables. But each pound of feed water at 100 deg. contains heat equal to the difference between 100 and 32, or 68 B.t.u., as it enters the boiler. Therefore, the amount of heat given to each pound of boiler feed converted into steam is the difference between the total heat (1,195.0 B.t.u.) and the heat of the feed water above 32 deg. (68 B.t.u.), or 1,195.0 — 68.0 = 1,127.0 B.t.u. Heat output during the test is, therefore, 100,000 × 1,127.0 = 112,700,000 B.t.u., neglecting, for the present example, the moisture in the steam.

Heat input is equal to the pounds of coal burned multiplied by the heating value of the coal. For instance, if during the test 12,375 lb. of coal were burned

containing 13,000 B.t.u. per lb. as fired, the heat input would be 12,375 × 13,000 = 160,875,000 B.t.u. In this case the efficiency developed, i.e., ratio of heat output to heat input, would be 112,700,000 ÷ 160,875,000, or 70.1%. Thus, it will be seen that to determine boiler efficiency it is only necessary to know amount and temperature of the water fed to the boiler, pressure (and temperature in case a superheater is included) of the steam, and the quantity and heat value of the fuel used in generating the steam.

In making efficiency tests many operators give a great deal of attention to the measurement of furnace and stack draft, gas and air temperatures, and gas analysis, with the idea, perhaps, that these data are required to determine boiler efficiency. Such data are needed to explain why results are poor or good, but they have nothing to do with determining efficiencies in an evaporative test. Collecting such data should not be allowed to interfere with the accurate measurement of essential items upon which the greatest effort should be concentrated.

Testing for Capacity

To test for capacity, both the heat output and the time must be measured. If in the foregoing examples, for instance, duration of the test is ten hours, the average rate of steam production would be 10,000 lb. of steam an hour from feed water at 100 deg. into saturated steam at 150 lb. pressure. In past years, rates of evaporation were commonly expressed in terms of boiler horsepower, or in per cent of builder's rating. But the arrangement of heating surfaces in modern boilers is such that the term boiler horsepower has little, if any, meaning.[1] However, an arbitrary equivalent of the delivered boiler horsepower is accepted as 33,472 B.t.u. per hr. With an average evaporation of 10,000 lb. per hr. of feed water into steam at 150 lb. pressure, the average heat output was 11,270,000 B.t.u. and the average boiler horsepower generated was 11,270,000 ÷ 33,452 = 337 b.hp. If "builder's rating" were 300 b.hp. the unit was operated at an average of 112.3% of rating.

Thus, to make a capacity test, it is only necessary to determine quantity and temperature of the feed water, duration of test, pressure (and temperature in case a superheater is included), and steam generated in a known time. Measurement and analysis of fuel used, analyses of flue gas, measurements of draft and gas temperature are not essential in making a capacity test, but such data are useful in arriving at an explanation as to why the capacity developed is high or low.

In the foregoing it is evident that efficiency or capacity developed can be determined without collecting much data. But if the test is to be of much help in boiler operation, enough data must be collected to make possible a complete analysis of losses. Succeeding articles will deal with equipment that has been found to be satisfactory in making all measurements and in securing data for complete analysis of boiler performance.

[1] *Power* agrees with Mr. Wood in condemning the use of "boiler horsepower."

For Success With Paint—

IF THE last paint withdrawn from any container is too heavy for use it shows lack of sufficient mixing before the first paint was withdrawn. Such paint should be reduced with linseed oil—not turpentine. Lumps of hardened or caked pigment in the bottom should be discarded unless they can be readily broken up and completely and throughly incorporated with linseed oil to make smooth, free-working and satisfactory paint.

"Skins" consist of dried-out vehicle. They should be removed and discarded before mixing is started. If the remainder of the paint proves to be too heavy, it should be thinned with linseed oil and a small amount of turpentine.

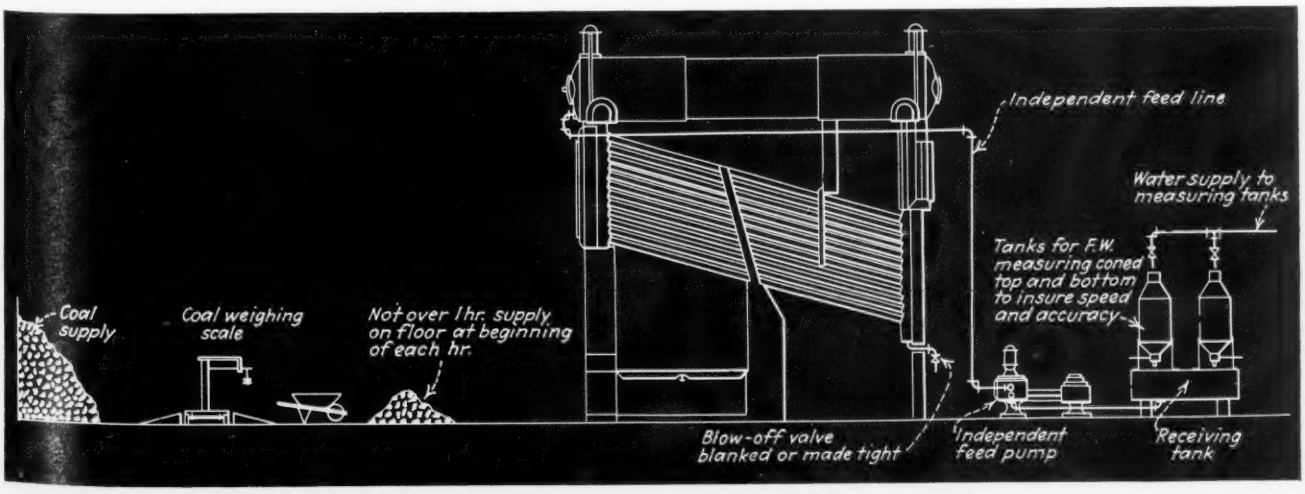
Paint that has become ropey or stringy and sticky in the container can usually be reconditioned by addition of linseed oil and a small amount of turpentine.

Paint that has become either partially or entirely congealed or hardened in the container should not be used, as the vehicle has lost its properties to form a protective film.

The temperature of the paint and the temperature of the surface on which it is applied should be the same for successful application. If warm paint is applied on a cold surface, trouble may be experienced from running, streaking or sagging. In addition, the fatty part of the paint may rise to the surface, producing a greasy film, which is difficult to coat over. If cold paint is applied on a warm surface, trouble may also be encountered because of the tendency of the paint to expand in volume. Again a greasy film may result, which will be difficult to coat over.

(Abstracted from an article by Francis M. Hartley, Jr., in "Dutch Boy Quarterly").

Suggested set-up for a simple boiler test


Coal supply
Coal weighing scale
Not over 1 hr. supply on floor at beginning of each hr.
Independent feed line
Water supply to measuring tanks
Tanks for F.W. measuring coned top and bottom to insure speed and accuracy
Blow-off valve blanked or made tight
Independent feed pump
Receiving tank

CHEMICAL DEAERATION

Power men everywhere are talking about chemical deaeration. How is it done? Can it replace physical deaeration? POWER has asked a disinterested and distinguished expert in the field of water treatment for the answers

THE cause and prevention of corrosion in steam-generating equipment has been the subject of extensive research in recent years, and resulting literature has been voluminous. Today the developed theory of the mechanism of corrosion, supported by plant experience, shows that corrosion can be controlled by attention to its causes.

Many creditable reviews of the theory of corrosion have been published, but it may be profitable to summarize the facts of greatest concern to the boiler-plant operator:

1. Iron and steel are soluble to a limited extent in water, even when it is pure and free from dissolved gases.

2. At lower pH values—i.e., increasing acidity—the solubility increases. Even in waters of relatively high alkalinity (about pH 9.6), corrosion can become progressive at high temperatures.

3. Dissolved oxygen combines with the dissolved iron, permitting the solution to become progressive at any pH value, and resulting in active corrosion.

4. As is the case with most chemical reactions, the velocity of these phenomena is tremendously increased as the temperature of the water is elevated.

5. The rate of corrosion is influenced by the accessibility of the metal and the film of corrosion products to the corrosive solution and to dissolved oxygen. This is in turn governed by velocity of flow over the metal and by the nature of the corrosion products.

6. The chemical and physical composition of metal has a marked effect on the acceleration of corrosion.

A complete statement would include pitting from anodic corrosion, acceleration by stress and other factors, but the phenomena described point to the two corrective measures most effective in combating corrosion: maintenance of high pH value, and removal of dissolved oxygen. Much evidence to substantiate these facts has been published.

The necessity for maintaining alkaline boiler waters has become axiomatic with operators, and the familiar pH indicator test is now routine in most plants. Methods of measuring pH depend on the properties of indicator dyes and the physical constants of electrodes and electrolytes. Exact knowledge of these data is based almost entirely on room-temperature observations; the pH of solutions at boiler temperatures cannot be measured by any present methods. The numerous equilibria which control the ionic composition of boiler water will shift in unknown ways as the temperature, pressure and concentration are increased. For instance, it is known that the neutral point of water is pH 7 at room temperature, but pH 5.7 at 425 deg. F.

Practical experience indicates, however, that corrosion will be minimized if the pH value of deaerated water is not less than 9.6, and that of the concentrated boiler salines not less than 10.6, after the samples have been cooled to room temperature.

Physical Methods of Deaeration

Numerous devices have been developed for the removal of dissolved gases by physical means. These are based on Dalton's law of partial pressure and Henry's law of the solubility, which states that the concentration of a gas in solution is proportional to the pressure of the gas above the liquid.

When the temperature of water is raised to the boiling point, the pressure above it consists entirely of water vapor; the gases are immediately flashed out of solution to an extent which is governed by their solubility and the completeness of their removal from the vapor space. The boiling point, and thus the flashing temperature, may be lowered by decreasing the pressure, above the water, or in other words by creating a partial vacuum.

When proper temperature-pressure relations are maintained and the flashed gases are adequately removed, these devices may be depended upon to reduce dissolved oxygen to concentrations that are undetectable by ordinary analysis and which cause negligible corrosion. Such appliances have, in the majority of cases, reduced corrosive non-condensible gases to a point where corrosion has not been experienced.

Proper operation cannot always be assured, however, and the limiting sensitivity of the Winkler method for dissolved oxygen is such that apparent "zero oxygen" water, as so determined, may in fact be definitely corrosive, especially at high temperatures. Moreover, deaerated feedwater may often absorb oxygen at various points before it reaches the boiler. In practice, active corrosion has been experienced at times in spite of repeated tests showing "zero oxygen" in the heater effluent, and has been the cause of much controversy and discussion, since in other instances deaeration has given

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Mr. Powell has abstracted this article (which will be concluded in July) from the forthcoming second edition of his book, "Boiler Feedwater Purification." All rights are reserved by the author.

OF BOILER FEED WATER

No. I—THE FACTS

By Sheppard T. Powell

Consulting Chemical Engineer,
Baltimore, Md.

SHEPPARD T. POWELL

A graduate of Rensselaer Polytechnic Institute, Mr. Powell specialized on water purification, sewage treatment, trade waste recovery and allied problems. He has since served as consultant on design and operation of water-purification systems for many high-pressure steam stations, having been associated with a number of major public utilities and industrial corporations. He collaborated in preparation of the report of the Water Planning Committee for the National Resources Board as special consultant on water quality, sewage and industrial waste treatment.

At present, and for the past seven years, in addition to his consulting work, he has been associate in sanitary engineering at the School of Hygiene (Graduate School), Johns Hopkins University.

Mr. Powell is chairman of the Boiler Feed Water Studies Committee sponsored by six major engineering organizations, chairman of the Water Purification Division of American Water Works Assn., a member of the Joint Editorial Committee on Standard Methods for the Examination of Water and Sewage, vice-chairman of the Maryland Section, A.I.Ch.S., fellow of the American Public Health Assn., and a member of many technical associations. He was Edgar Marburg lecturer in June, 1934, before the A.S.T.M. at Atlantic City. In addition to a number of papers and monographs on chemical engineering and sanitation problems, he is author of the textbook, "Boiler Feed Water Purification."

complete protection apparently under the same operating conditions.

Chemical Methods

Concurrent with the use of mechanical deaerators other methods for removing oxygen from solution have been developed. This development has been accelerated by the inadequacy or defective operation of deaerating apparatus, which required a supplementary scrubbing-out of the last traces of dissolved oxygen by other means. Such methods have been especially important in the operation of high-pressure installations.

A number of novel processes have been proposed. Two authorities on corrosion suggest repeatedly saturating the water with carbon dioxide or nitrogen and evacuating. A patent has been granted for the removal of oxygen from steam with metals and specially prepared metallic oxides. A recent German patent for degassing boiler waters covers the use of activated charcoal and heat. Attention has also been directed to inhibitors or passifying agents, such as chromates, but the protective film on which these depend for their efficacy will not generally withstand high temperatures. Oxygen combines with many substances at room temperature, and at high temperatures practically any oxidizable material is readily attacked by oxygen, even when it is in aqueous solution at low concentration. It is a logical development, therefore, to use chemical reducing agents for the deaeration of feed water.

Use of Iron and Iron Compounds

The first and most obvious chemical method was a duplication of the process of corrosion, in which the water was "deactivated" by allowing it to come in contact with iron sheet or scrap. These devices have a certain limited usefulness in connection with heating boilers, but because of the slowness of the reaction the capacity of the units is small. They have been little used in this country because of the size of the equipment required and inherent difficulties of operation.

Soluble ferrous salts are fairly stable with respect to oxidation by air, but the insoluble ferrous hydroxide is a rapid and powerful reducing agent, and has had frequent mention in the literature as a deaerating reagent. A detailed account of its application has been given by one of the larger public utilities. At this plant the reagent was prepared in two air-tight tanks, operating alternately, by adding caustic soda and ferrous sulphate to condensate, mixing, settling eight hours, and decanting the sodium sulphate. The precipitated hydroxide was washed four times by a similar decantation of condensate, and then drawn into the hot well as needed by condenser vacuum. It was found that a slight excess would serve as a reservoir of oxygen-consuming power. Disadvantages of this treatment are the laborious preparation of reagent and the increase of suspended solids in the boiler because of the precipitated ferric hydroxide.

A common ingredient in boiler-compounds is often designated as "organic colloids"—a term covering several hundred thousand chemical compounds, since "organic" only specifies carbon compounds and suggests animal or vegetable origin, while "colloid" refers to a state of dispersion. Most of these substances which have been found to have real merit in boiler-water treatment belong to two large groups of compounds—starches and tannins.

The effect of colloids on the crystallinity of scale has been described in several recent papers and is not pertinent to this discussion. One author cites evidence that these substances inhibit corrosion by repressing the ionization of electrolytes. Some organic compounds, however, are powerful reducing agents, and it is these compounds which retard corrosion most effectively because of their ability to remove dissolved oxygen from the water.

The starches do not contain any of these reducing

groups. Tannins, however, are good reducing agents, as their relation to pyrogallol will indicate. In hot alkaline solution, tannin breaks up into glucose and five molecules of tannic acid; the tannic acid yields ten molecules of gallic acid, which in turn produces pyrogallol and carbon dioxide. Only one of the large group known as tannins has this particular numerical relation, but the sequence is the same for all. The alkaline solution of pyrogallol is familiar in gas analysis as a quantitative and rapid absorbent for oxygen.

Investigators have measured the oxygen-absorptive powers of pyrogallol, tannic acid, and ten tannin extracts. Using solutions at room temperature and containing 20% of caustic potash, they found that one gram of pyrogallol absorbed 0.37 grams of oxygen, while one gram of liquid chestnut-oak extract (weight reduced to dry basis) absorbed 0.29 grams of oxygen.

It is claimed that one gram of a commercial boiler compound removes 0.12 grams of oxygen. The absorption increases steeply as the solution is made more alkaline, reaching half its maximum value in the presence of 85 parts per million of sodium carbonate and becoming constant at 855 parts per million of sodium carbonate. Other experimenters found that red-oak extract in alkaline water greatly reduced corrosion.

There is thus a sound basis in theory and practice for the use of tannins in the chemical deaeration of boiler water, if such application is governed by a knowledge of their oxygen-consuming power. It has been pointed out above, however, that these substances release carbon dioxide, and their eventual decomposition products are unknown. For this reason they should be used with discretion.

Deaeration With Compounds of Sulphur

Materials containing sulphur are widely used in analytical and applied chemistry because of their oxidizing or reducing powers. Sodium sulphide has been mentioned for the chemical deaeration of water, presumably because it contains the most reduced form of the element. The sulphur compounds which are more familiar in this application, however, are sulphur dioxide, sulphurous acid and the sulphites.

Sulphur dioxide is an acrid gas obtained by burning sulphur, and is present in flue gas. It dissolves in water to form sulphurous acid, and in alkalis to form sulphites. The acid will readily decompose into sulphur and sulphuric acid, but the alkaline sulphites absorb oxygen and yield sulphates. Sulphur dioxide has been used for chemical deaeration, and a German patent covers the treatment of condensate returns with sulphur-burner gas while a blanket of nitrogen is maintained to exclude oxygen. In German practice it was found that deaeration with sulphur dioxide was slow unless excesses were used, or the reaction was accelerated by heat or copper catalysts. Therefore, either sodium bisulphite and caustic soda, or sodium sulphite, were recommended. In this country, sulphurous acid was tried out for oxygen removal in an experimental boiler. Of all of the forms of sulphur, however, sodium sulphite has been most widely discussed and applied as a reagent for chemical deaeration.

Sodium sulphite is a white salt, with a maximum solubility corresponding to a 28% solution at 92 deg. F. Both the crystalline and the anhydrous forms are obtainable, but since the crystalline salt contains 50% by weight of water and is not easily stored and handled, it is not to be recommended for plant use. The bisulphite or acid salt is also available, but is changed to the normal sulphite by the alkalinity of the water or additions of caustic. Since the normal sulphite forms a solution which does not greatly modify the pH of the feedwater, and is not as corrosive as the acid salt, it is more generally used.

The anhydrous sodium sulphite is stable in dry air even at 212 deg. F., but oxidizes slowly to the sulphate in moist air at 60 deg. F. It should therefore be stored in a dry place. The purity of the commercial salt may be assumed to be 90% for the purpose of calculation.

The oxidation of the aqueous solution is a special type of chemical reaction and has accordingly been the subject of considerable research.

Strength of Solutions

The rate at which a 20% solution of sodium sulphite absorbs oxygen is negligibly slow, and the chemical in the solution tank will keep better if made up at approximately this strength. Oxygen is absorbed most rapidly by solutions of 4 to 10% in concentration; within this range the sulphite will take up oxygen as fast as the water can dissolve it from the air. While losses from this cause will not be rapid unless the liquid is turbulent, it is advisable to provide tight covers for all parts of the feeding system.

These studies also throw light on the efficiency with which sodium sulphite may be expected to remove oxygen from feed water and boiler salines. When the solution is made weaker than 4% (40,000 parts per million) the speed of the reaction with oxygen decreases moderately, and at 250 parts per million it begins to drop sharply, suggesting that concentrations permissible in the boiler might absorb oxygen rather slowly. On the other hand, the high temperature of the boiler water opposes this tendency and probably speeds up the reaction tremendously, since the velocity is doubled by an 18-deg. rise in temperature from 32 to 50 deg. F.

It is also possible to accelerate the process greatly by adding minute amounts of catalysts. Some common reagents which show this influence are, in the order of their efficacy, the sulphates of copper, nickel, manganese, iron and cobalt. Indeed, it is suspected that catalysts in the form of impurities are always required to make the reaction proceed. Copper sulphate has been widely used and recommended for this purpose in the use of sulphites for deaeration, but it should not be introduced into steam-generating equipment because of the danger of localized deposits of copper and consequent rapid galvanic corrosion. Another important factor is the pH of the solution, and in this respect it is fortunate that the usual pH of feed water and concentrated boiler water is favorable to the absorption of oxygen by sodium sulphite.

[In July will appear the second, and concluding, installment, dealing with the practical application of sodium sulphite in boiler feed-water deaeration—Editor]

AUTOMATIC STEAM TURBINE

By R. W. P. Leonhardt
Berlin, Germany

IN THE new power-house of Mitteldeutsches Kraftwerk, Magdeburg, Germany, house-service energy is supplied from the 10,000-volt main station bus-bars through three transformers which step down to 380 volts. In event of a breakdown on the house-service main, operation of many essential auxiliaries would be endangered. To improve reliability, an emergency turbine-generator set, arranged for automatic starting, was installed and connected in parallel with the house transformers. Automatic starting of this turbine makes it possible to have the unit supplying energy to important auxiliaries within 30 sec.

The 3,000-r.p.m. turbine is supplied with steam at 400 lb. pressure and 770 deg. temperature, and will develop its full output of 560 kw. even though pressure should drop to 280 lb. A 700-kva., 380- to 420-volt generator is directly connected to the turbine.

When voltage fails across the 10,000-volt bus-bars, an under-voltage relay trips. A retarding device then interrupts the process of switching for a duration of 5 sec., so that the turbine does not start up unnecessarily should full voltage reappear across the busbars. If voltage fails to reappear, a master relay switches into the circuit, causing the automatic starting process to continue. At the same time the master relay acts, a signal "Caution Set Starting," is indicated in the main control room.

Individual phases of the automatic starting process must be completed within a certain time, otherwise it is assumed that something is out of order. In such event the attendants in the control room must shut down the set manually. For supervising the prescribed starting time there is a supervising relay which comes into action with the starting signal and indicates disturbances through pilot lamps in the control room.

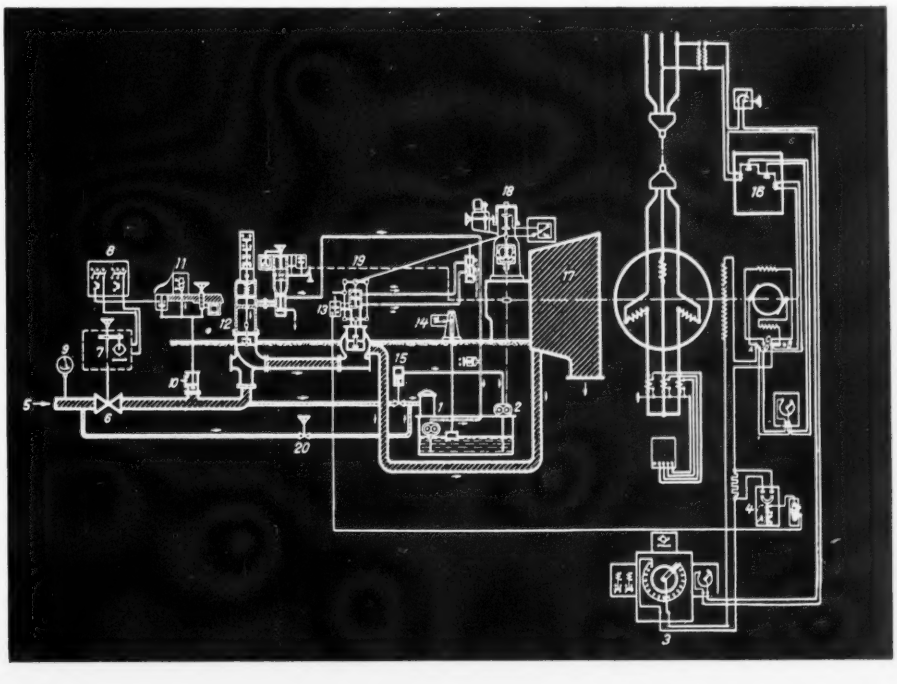
The master relay has an auxiliary contact which connects the lifting magnet (11) across voltage, as shown in the diagram. Thus energized, the magnet closes the pipe-line ventilating valve (10). After the set is started the master relay trips, whereupon the lifting magnet is de-energized, but live steam pressure now acting on the ventilating valve keeps it closed. When this valve is closed a control contactor (8) is put across voltage. This contactor switches in motor (7), driving the main steam valve (6), which it opens, thereby admitting steam to the auxiliary oil pump (1), and to the starting valve (12).

When oil pressure builds up, it lifts the pre-lift cone of the starting valve and starts the turbine. When the turbine reaches a certain speed, the throttle valve (13) assumes its no-load position. This results in an increase in pressure behind the starting valve (12), thus, balancing the pressure on the valve and permitting oil pressure to open the main valve cone. With the main valve wide open, the turbine quickly reaches its normal speed. As pressure builds up on the main oil pump, valve (15) is closed, shutting off steam to the auxiliary oil pump.

When throttle valve (13) assumes its no-load position it operates a contactor which causes the automatic field-weakening gear (4) to operate to strengthen the generator field. This gear automatically weakens the field of the main generator while the turbine is at standstill or during starting.

As soon as the voltage has reached 420 the three house transformers are disconnected and the main breaker of the emergency generator is closed. Voltage drop occurring the moment the main breaker is closed is arrested by short-circuiting the main field regulator (3), and by adjustment of the voltage regulator.

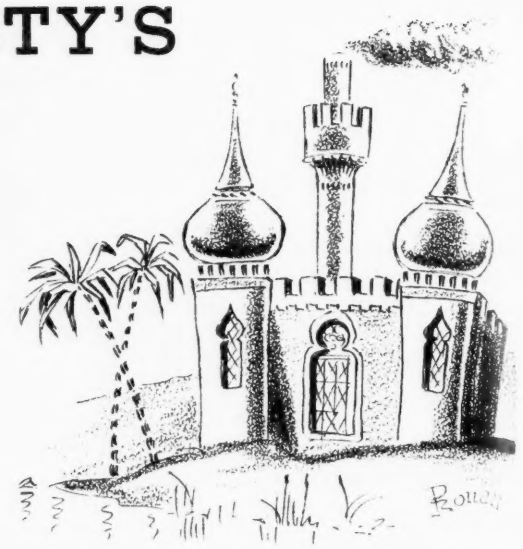
From standstill to switching in of the automatic field weakening gear (4) takes 16 sec. It takes 2 sec. more to connect the generator across the house-service main, and 10 to 12 sec. to establish normal 380 volts.



Automatic emergency turbine set-up

(1) auxiliary oil pump, (2) main oil pump, (3) main current regulator, (4) automatic field-weakening device, (5) live steam pipe, (6) main steam valve, (7) control for valve, (8) control relay, (9) pressure gage, (10) ventilating valve, (11) lifting magnet, (12) automatic starting valve, (13) throttle valve, (14) oil level gage, (15) valve for auxiliary steam pipe, (16) Tirrill regulator, (17) turbine, (18) speed-adjusting motor, (19) operating rods for safety valve, (20) by-pass valve.

HIS MAJESTY'S POWER HOUSE



By N. L. Rea

Contract Service Dept.
General Electric Co.

ONCE upon a time an eastern potentate decided that he needed a power plant for his palace and capital city. This seemed the fashionable thing to do. Other countries had 'em, so why not he? Orders were, therefore, issued and results looked for.

Bright young native . . .

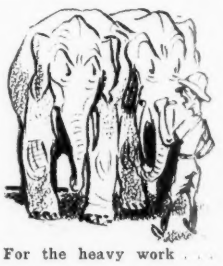
A bright young native with a diploma in civil engineering was secured and turned loose on one of the rivers. Waterwheels, generators and other equipment were ordered, transported many weary miles by main strength and ignorance, and it was high time for the electrical erector to do his stuff.

Luckily an "old timer" takes little for granted. His check showed the downstream end of the canal some 5 ft. higher than where it started at the dam 4 mi. away. A little thing like that hadn't been discovered by the native engineer.

5 ft. higher here . . .

Then the pot boiled over for sure. Something happened to the native son, and the electrical erector was told to do what was necessary. He had discovered the error, therefore should correct it. The previous work had ruined the good side of the river, so a new canal must be dug through mean going. A company of sappers was detailed, but they had nothing but wooden sticks and shovels. After several months of talk and argument, picks and shovels were delivered. But these were such an improvement that the local sheriff promptly stole them for distribution to his friends and henchmen. Another long delay, and a second consignment arrived.

More talk, pleading and argument secured two elephants to do the heavy work. An elephant could do the work of a hundred men, but harness was necessary and soon wore out. There were hundreds of sets of harness in the royal stores, but His Royal Highness, knowing his people, had decreed that his personal signature was necessary before the royal stores could be drawn upon. A request from the erecting engineer went to the Grand Vizier. He thought it over and waited for a propitious moment during a royal audience to present the request, for, of course, His Royal Highness must be in good humor before he could be bothered by routine. It was a long, hard ride to the Capitol, and if the erecting engineer wished to come in person to plead his case, he might cool his heels a week or more before he got an audience.



For the heavy work . . .

On the other hand, His Royal Highness once broke up a royal audience and went in person to the door of the anteroom to summon the erecting engineer. He had overheard the court attendants mention that the engineer had let his beard grow. A power plant could wait, but a new beard demanded immediate royal inspection and comment.

After waiting for months for elephant harness, the erecting engineer decided to make it himself. Sheep skins were tanned for leather, the women spun cotton into yarn, yarn into cord, and from the cord made webbing. The blacksmith hammered out the iron parts. Two weeks of work made a harness complete, while one from the royal stores might come in three months —or never.

Two I-beams were ordered from half across the world for the forebay gate supports. They landed at an out-of-the-way seaport and were turned over to a contractor who agreed to deliver them at the power house. Allah willing, over miles and miles of mountain trails.

Royal beard inspection . . .

Weeks and months passed and no beams. A tracing party set out. The record of the passing of the beams was

fairly clear to a point about halfway. Careful search finally located them, resting across a well in a little village several miles from the main road. The headman was accused of stealing the beams and threatened with the consequences. "But, Master, I am the contractor! When I got home it was time to plant the crops. If we do not plant we starve. There was not time to deliver the beams between planting and harvest, so we await the harvest. Afterward, I will bring the beams as agreed."

Highwayman's end . . .

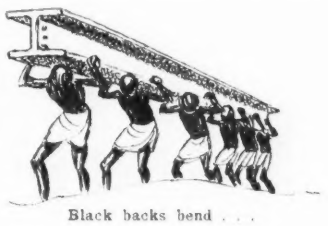
In due time the beams arrived. Cement came in by pack trains of yaks. Otherwise local products had to be used, with all sorts of makeshifts.

There were guards aplenty, and the erecting engineer, being a favored employee of His Royal Highness, was kept from harm. There were highwaymen for the unwary, but His Royal Highness made proper examples of highwaymen when captured.

Escort to the railroad . . .

A box about the size of a barrel was made from strap iron. The robber was doubled up inside and riveted in. Then the cage was hung on a pole at the scene of the crime and a guard kept to prevent friends from rescuing him before death released him from the tortures of hunger and thirst. Such treatment certainly decreased local enthusiasm for thieving.

All things come to an end, and eventually the plant was placed in satisfactory service. Then, and not till then, was the engineer given his release and safe conduct and an escort to see him safely back to the railroad.



Black backs bend . . .

Uniflow on Vacuum or Off by Lever Shift

A 500-600-i.hp. uniflow engine at the Charlestown (Boston), Mass., plant of Davidson Rubber Co. is shifted instantly between condensing and non-condensing operation by throwing over a lever controlling the exhaust valves; exhaust eccentrics do not have to be shifted by hand at any time. Selected for its high economy, the engine is operated non-condensing whenever steam is required for building heating.

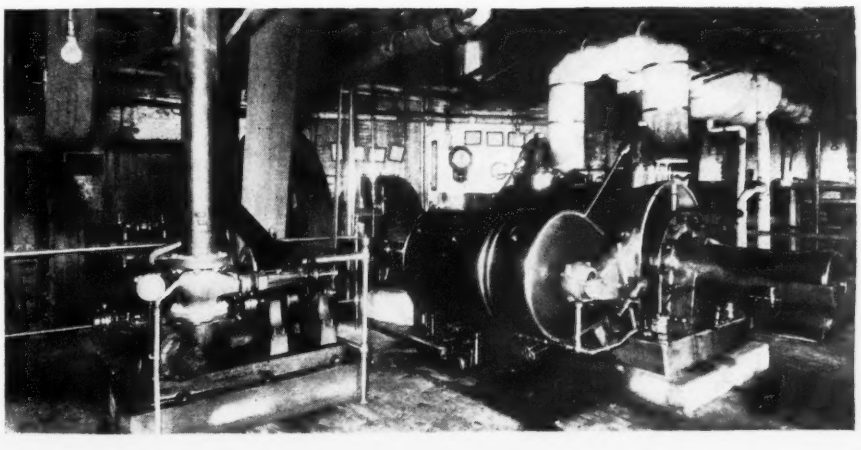
The original engine was replaced by a corliss unit in 1905. This in turn has been supplanted by a 200-r.p.m. Nordberg 22x24-in. uniflow with heavy flywheel. Supplied with steam at 110 lb. and exhausting into a Croll-Reynolds surface condenser at 27 in. vacuum, this unit will deliver 600 i.hp. A Binks cooling tower on the roof cools condensing water, which is circulated by a 6-in. Morris pump belted from the engine shaft. The condenser is served by an evactor and float-operated condensate pump. A 12½-kw. generator is also belted to the engine. Recent tests show a steam rate of 15 lb. per i.hp.-hr. at full load.

The plant is started on vacuum, both condenser and circulating pump being flooded at all times from the tower basin. Over cold nights or weekends, water is drawn into a storage tank which automatically fills the system before starting. The same supply makes up for tower evaporation, 1 to 2% of the total. This arrangement has worked out well during the past two winters in spite of several days of sub-zero weather.

Costing about $25,000, this installation has halved fuel bills, thus will pay for itself in five years, meanwhile giving ample power and better regulation for the light machinery upstairs, driven by 24-in. belt from the engine pulley. Even with wide load fluctuations caused by the heavy mills, driven by chain from the geared lineshaft, voltage and lights hold steady, showing good regulation. A magnetic clutch on the engine shaft extension stops the mill shaft at once in case of accident, and similar apparatus stops the engine.

With steam at 30 cents per 1,000 lb., fixed charges at 12%, and no additional wages or credit for heating, cost per i.hp.-hr. is, according to the engineers, about $0.006 and considerably less than purchased current or any other generating method. The two h.r.t. boilers are stoker-fired and operate at good rating and 75% efficiency. Process steam at 100 lb. is also supplied for vulcanizing and other purposes. City water is purchased, but the amount has been greatly reduced, a cost element not included in the above. There are also enough returns and auxiliary steam to maintain a high feed-water temperature.

Planned by George D. Brown, master mechanic, the plant was installed by Starkweather Engineering Co.



PROPER, UP-TO-DATE MOTORING

By H. M. French
Industrial Engineering Dept.,
General Electric Company

EVERY industrial plant manager is interested in reducing operating costs. Proper motoring is one good way to do it. Better use of equipment, enclosed instead of open motors, maintenance of high power factor, and synchronous instead of induction motors—these are all ways to attack the problem.

Many machines have been equipped with motors larger than required for their heaviest probable job, "just to be safe." The owner paid an efficiency and power factor tax year after year. Bad effects of overmotoring are emphasized by a survey in one plant where power lines overheated. Investigation showed a plant power factor of approximately 0.70. Motor loads were studied in an attempt to avoid buying new cables. A motor load survey made with meters showed a majority underloaded (some only about 30% loaded), while others were overloaded. Motor rearrangement saved the cost of new cable.

This case shows how a small investment for testing instruments will often save many times their original cost. In plant-power surveys, instrument readings form the basis of all investigations. In the maintenance department they are almost indispensable.

Enclosed motors chiefly reduce maintenance rather than power costs. In many plants, motors must operate in dust, dirt, moisture, corrosive gases, etc. Standard open motors in such locations involve high maintenance costs due to overheating caused by reduced ventilation, short circuits, burning or rapid wear of collector rings, commutators and brushes and to other difficulties. Motors are available with various types of partial and total enclosures, some of the latter with fan-cooling. Frame sizes, rating for rating, in many cases are identical with those of open motors. For larger ratings, slightly larger frame sizes are required to give the same output.

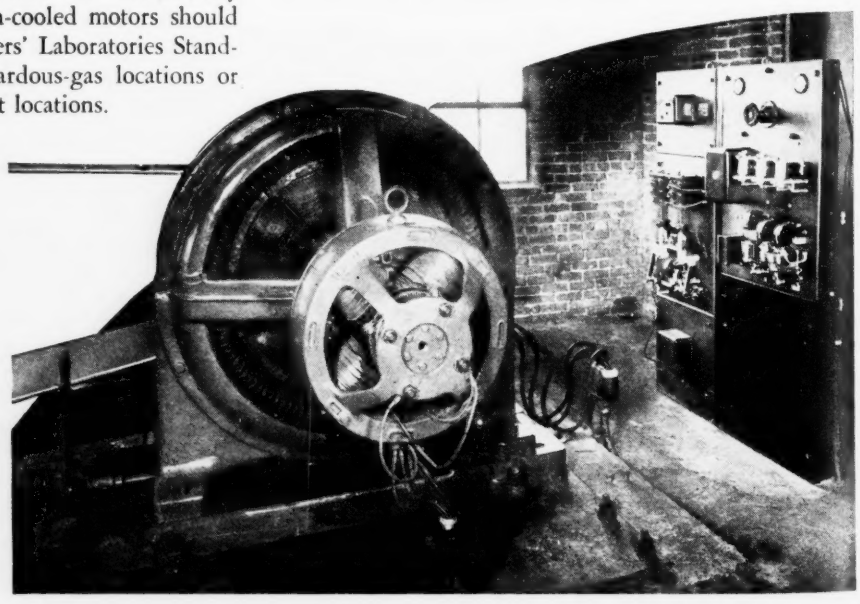
Explosive gases or dusts create a hazard to personnel and equipment. Where these are encountered, totally enclosed or totally enclosed fan-cooled motors should be used, built to the Underwriters' Laboratories Standards for Class I Group D hazardous-gas locations or Class II Group G hazardous-dust locations.

Maintenance of high power factor, not particularly important ten years ago, has grown to be a real item in operating expenses, particularly when power is purchased. Many power companies' rates include power-factor adjustment clauses, for example, one common form of power contract adds or subtracts 0.5% for each per cent that power factor is above or below 85. For a plant using 260,000 kw.-hr. per mo. at a $0.02 rate, the difference between 75 and 90% p.f. is $4,680 annually in the power bill.

Induction-motor power factors vary widely according to load and speed, being higher for high-speed well-loaded motors. Hence, high-speed fully loaded motors are desirable wherever possible. Gear motors, which comprise a high-speed motor and a reduction gear mounted as a unit, frequently can be used to advantage. Therefore, when a power-factor survey is made, induction motor speeds and loads should be checked. After induction motors have been arranged to best advantage, further improvements in power factor must be obtained by using capacitors, synchronous condensers, or synchronous motors. Capacitors are compact, have no moving parts, and require little or no attention. Synchronous condensers, like capacitors, supply 100% leading reactive kva., but require some attention, being rotating machines without mechanical load. Synchronous motors operating at either unity or leading power factor perform the same function as capacitors or synchronous condensers at a lower cost per leading reactive kva. At the same time they are desirable drives for constant-speed power applications, especially at low speeds where induction motors have low power factor.

Synchronous vs. Induction

Substitution of synchronous for induction motors, in addition to correcting power factor, improves efficiency, particularly at part loads, and gives constant-speed operation. Efficiencies of synchronous motors are from 1 to 3 points higher than those of corresponding induction motors. With a difference of, say, 2% in a 200-hp.



A 200-hp. synchronous motor driving a large mine-ventilating fan by flat belt

PAYS ITS OWN WAY

Better use of existing motors, improving power factor and substituting synchronous for induction motors make large savings in operating costs

motor, the synchronous motor on a basis of 4,000-hr.-per-yr. operation and power at $0.02 per kw.-hr. shows a saving of $800 per year. This amount capitalized at 10% would justify an increased expenditure of $8,000.

Synchronous motors operate at constant speed. For many applications, this helps to obtain maximum output from the driven machine. For low-speed drives, direct-connected synchronous motors are low in first cost, save space and eliminate gears that must be used with high-speed motors. Elimination of gears improves efficiency and reduces maintenance costs. For applications requiring lower speed than can be economically obtained from synchronous motors, or for motors of relatively small ratings, the gear motor, previously mentioned, is particularly adapted. This unit combines the high efficiency and power factor characteristics of a high-speed motor with an equally highly efficient form of gearing. It is available in sizes from fractional up to approximately 100 hp., with output shaft speeds from 600 down to 11 r.p.m. and lower. It may be obtained in all forms of electrical and mechanical construction to suit any application.

Examples

Here are several instances of savings resulting from modernization:

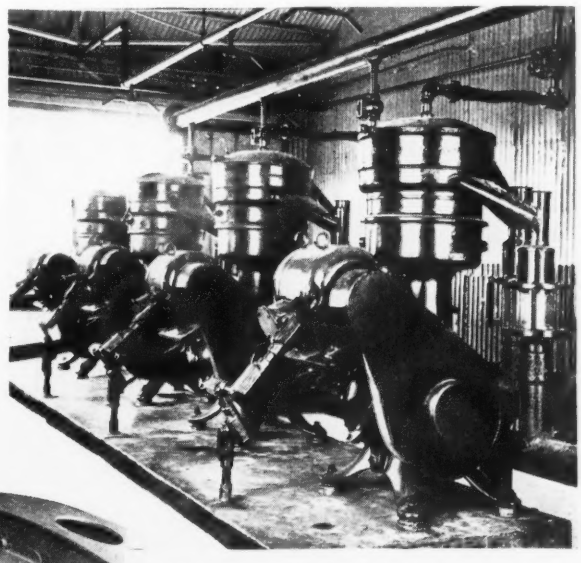
A California paper-mill's modernization investment is paying a 27% annual return. This plant manufactures tissue paper for fruit wrappers. Before modernization, it was operated by induction motors, power factor ranging between 0.44 for light and 0.80 for heavy load conditions. After tests, it was estimated that by substituting synchronous for induction motors on five Jordans and four beaters a possible saving could be made of $3,500 per yr. This amount represented 25.7% on total investment including installation costs.

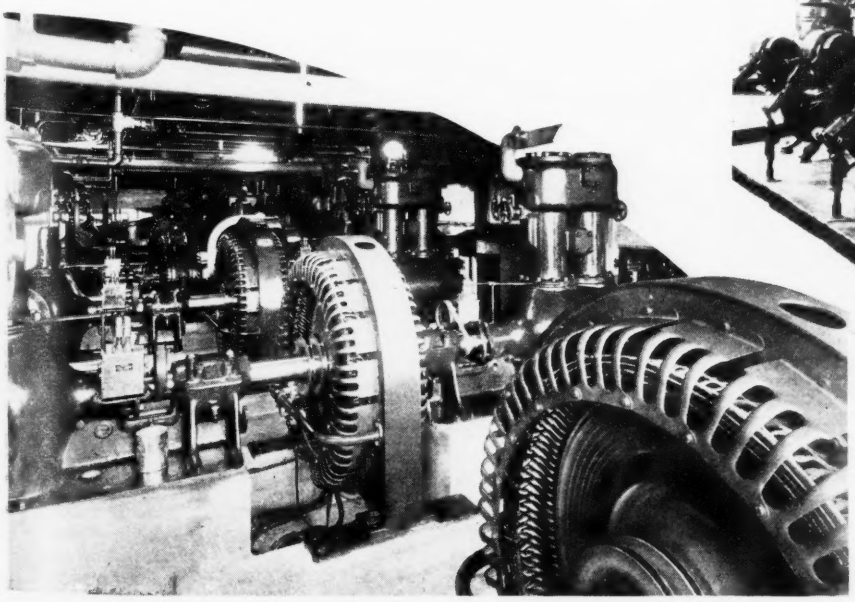
Three new synchronous motors were purchased, together with new rotors and necessary parts to change the four beater motors to synchronous units. Additional control equipment was also required. In order that the plant officials might calculate accurately the return on their investment, a wattmeter, power-factor meter and a demand meter formed a part of the order. As a result of this modernization, plant power factor now averages 99.8% and the annual saving is $3,800 per yr., a return of 27% on the investment. Of this, $2,600 is due to improved power factor and $1,200 because of better efficiency.

A 3-year modernization program conducted in a machine-tool plant in Illinois consisted principally of changing from lineshaft to individual drive of many machines and rearranging machines already equipped with individual motor drives. Expenditure for this work was approximately $35,000, including equipment and installation. The savings exceed $11,000 annually, or slightly over 31% return on the investment.

Replacement of manual control by automatic equipment in a Nevada copper mine more than paid for itself in the first year. In operating this mine, it was necessary to pump approximately 1,200 g.p.m. of water from three different levels. Duplicate pumping equipment was installed at each level so that if one pump was out of service the other would be available for immediate use.

Mine corporation officials felt that replacing the manual control would remove the mine-flooding hazard





Above — Four explosion-proof motors for hazardous gas locations connected to oil centrifuges by flat belts

Left—Three 150-hp. and one 100-hp. synchronous motors driving ammonia compressors in an ice-cream plant

due to human error in operating existing control equipment. The change to automatic control was made for approximately $8,000. It reduced operating costs over $10,000 a year. In addition appreciable savings in maintenance on pumps and control equipment were effected.

At Chattanooga, Tenn., packing and ice-manufacturing plant engineers checked up on compressor drives in their two plants. As a result both plants were completely modernized with new motors and control. Synchronous motors replaced former compressor drives, and high-speed modern induction motors were installed on other machines. A year's operation with the new equipment showed a saving over the previous year's costs of $9,700 at one plant and $4,500 at the other. Improved operating conditions and electrical equipment paid for within one year is the record of this installation.

Looking for ways to save money, a mining company in Ohio found that an old drive on one of its large ventilating fans could be profitably modernized. At a cost of $3,258 a new synchronous motor and control were installed. They saved $4,500 annually—$1,500 through higher efficiency and $3,000 through improved power factor—or a 138% return.

Total savings of approximately $3,400 per year, or 36%, on an investment of about $9,400 are expected in a California flour mill. Lineshafts were formerly driven by wound-rotor induction motors which had been operating for about 15 hr. per day. Modernization included new rotors, exciters and magnetic control to convert the induction motors into synchronous machines operating at 80% leading power factor.

These and other installations all go to prove that modernization, intelligently directed and carefully done, provides great money-saving opportunities.

Here's a Unit for Judging Compressors

By Arthur Korn

WHEN the user or manufacturer of a compressor has determined by tests the compression efficiency, volumetric efficiency, or mechanical efficiency of his machine, the figures in themselves mean little to him unless he has something to compare them with. 100% efficiencies cannot be obtained. What then can be obtained, and what is being obtained, with similar compressors? Is performance of this particular compressor above or below commercial standards? I think one can properly speak of such standards, for there is not as much divergence in efficiencies as is generally supposed.

Let it be said at the start that volumetric efficiency is really a misnomer. It does not signify efficiency at all. Even engineers who ought to know better often take volumetric efficiency tests, especially on air compressors where it is easily done, and from these judge the merits of a compressor. A lowered volumetric efficiency means a lowered output, but it also means lowered power requirements, although not quite at the same rate. Fig. 1 shows volumetric efficiency at different pressures as determined by tests. For all compressor displacements above 20 c.f.m., there seems to be little divergence, so that the values given in the chart can be considered fair commercial standards.

Compression Efficiency Important

More important is compression efficiency, i.e., ratio of work necessary to compress a gas with perfect cylinder cooling (at a constant temperature) to work actually expended in a process that is accompanied by a rise in temperature. This is easily determined for all perfect gases and superheated vapors which follow a simple polytropic law. In the upper part of Fig. 2, the isotherm shows horsepower theoretically required to compress 100 c.f.m. of gas at constant temperature for compression ratios of 1 to 19. Due to imperfect cylinder cooling, actual compression horsepower is higher, as shown in the chart by the upper curves with a polytropic exponent of 1.3 and 1.4. It is rarely as low as the 1.2 curve. There is no way of effectively reducing the difference between the isotherm and polytropic curves except by 2- and multi-stage compression. In that way great savings are made. Horsepower requirements for 2-stage compression and polytropic exponents of 1.2, 1.3, and 1.4 are shown on the chart, and the savings thereby effected can readily be seen.

It must be borne in mind that this chart is based upon atmospheric suction pressure. In case suction pressure is higher than atmospheric, values given in the chart must be increased in the ratio of absolute suction pressures. If suction pressure is lower than atmospheric, horsepower values must be reduced correspondingly.

Why Not Friction Hp.?

Text books show how to compute theoretical horsepower required to compress a gas; tables and charts have been published to determine that horsepower to decimal points, but they give no information on how to correct these figures to take care of frictional losses. In vain will one search handbooks and magazines for information. 90% mechanical efficiency is usually considered high, 75% as low. There are compression ratios and compressor sizes for which 40% mechanical efficiency must be considered extremely high. Contrasting with these wide and unknown variations frictional horsepower for a given compressor remains nearly constant for all pressures. I have made tests over a number of years with the product of one manufac-

turer and have charted test results published in engineering magazines during the last 25 yr. I found that friction horsepower of a compressor when running under no pressure can be expressed in the simple formula:

$$Hp._{fric.} = 105\ Displacement^{\frac{3}{4}}$$

(displacement in c.f.m.)

This formula seems to hold true with great accuracy for any kind of a compressor, whether vertical or horizontal, single- or double-acting, single- or multi-cylinder, single or multi-stage. It applies to vapor compressors as well as to gas compressors, and its range extends from the smallest household refrigeration compressor to the largest air compressor ever built. However, it must be noted that the horsepower of very small compressors may vary considerably. Tightening a stuffing box can increase the horsepower to twice its value. Also no check has been made on CO_2 compressors, which due to their relatively small cylinder size and high pressure may be in a class by themselves.

On the basis of this formula the lower part of Fig. 2 has been worked out. It will be seen that friction horsepower curves for various compressor displacements increase with pressure ratios. This is largely due to falling off of volumetric efficiency at higher pressures. It is obvious that, with a reduced output and a friction load remaining nearly the same, friction carried by each cubic feet of gas must increase. This is, by the way, the only reason why a low volumetric efficiency has any adverse effect on over-all efficiency of a compressor. Since volumetric efficiency of 2-stage compressors declines but little as pressure increases, it is natural that friction horsepower curves should show less increase with higher pressures.

Eliminate Guesswork

Use of the charts should prove helpful. Not only do they eliminate the tedious job of figuring power requirements, but also eliminate guesswork as to friction losses (which may even exceed compression horsepower). Divergence of friction curves shows the uncertainty and possible error involved for small compressor capacities. In the compressed air field, a given work may sometimes be accomplished by either a large volume of air at low pressure or by a smaller volume at higher pressure. Then the question arises as to most economical volume and pressure conditions. This problem can not be solved unless total horsepower necessary for compressing a cubic foot of air to a given pressure is known. In such cases the chart will be indispensable.

It is to be hoped that the present custom of expressing mechanical efficiency as the ratio of indicated horsepower to brake horsepower will be discontinued, because it is utterly misleading. For instance, of two compressors of equal capacity, compression ratio and mechanical design, therefore of the same friction load, the one with greater indicated horsepower because of lower compression efficiency will show higher mechanical efficiency. This, of course, is ridiculous, for mechanical parts have not improved simply because the compressor is consuming more power. If instead, *specific friction horsepower* be given, that is the friction horsepower carried by each cubic foot of gas compressed, a real comparison of mechanical merits could be made.

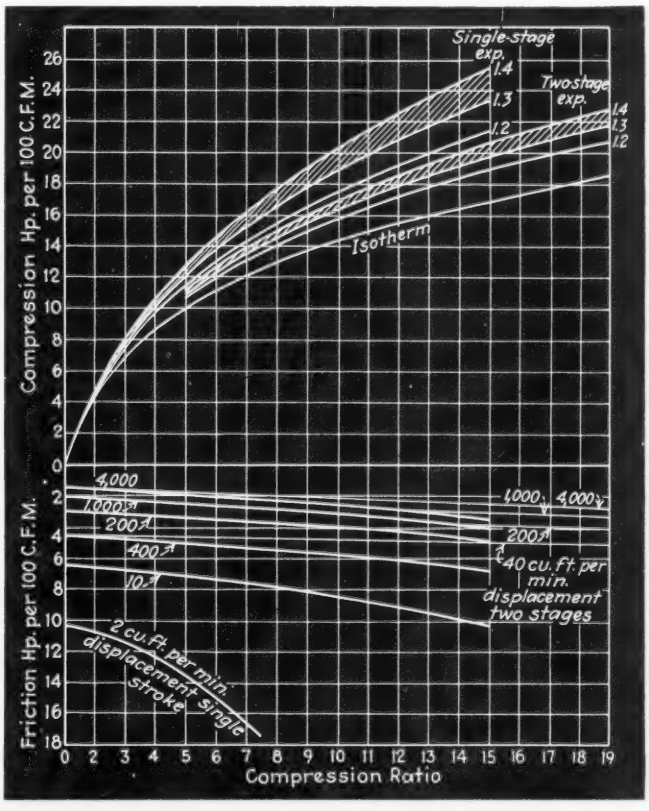


Fig. 2 (Above)—Friction and compression horsepower for various compression ratios, based on atmospheric suction

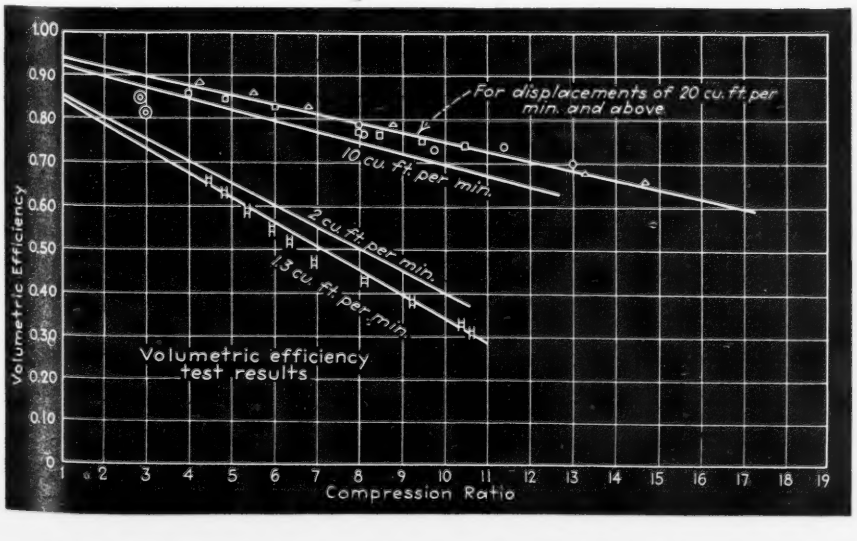

For displacements of 20 cu. ft. per min. and above
10 cu. ft. per min.
2 cu. ft. per min.
1.3 cu. ft. per min.
Volumetric efficiency test results
Volumetric Efficiency
Compression Ratio

Fig. 1 (Left)—For displacements over 20 c.f.m., volumetric efficiency varies only with compression ratio

KNICKERBOCKER

A SHORT time ago I visited friends in Knickerbocker Village, the new $8,500,000 slum-clearance project that Fred F. French Co. built in the lower east side of New York. About 50% of its cost was an R.F.C. allotment, consequently the Government was active in design and construction and set rental at $12 a month per room. The apartments are far superior to surrounding houses, yet money has not been wasted.

Two similar red brick 12-story buildings, separated by a children's playground, occupy about 2¼ acres on a 5-acre plot. Each is built around a large landscaped court, Fig. 3; each is divided into six units.

No wonder they called this project a village, for here 6030 rooms house 1593 families. In this concentrated area 4,000 people must be provided with all service facilities for comfortable living—light, heat, hot and cold water, refrigeration, incinerators, sewage removal, elevators and ventilation. There are also recreation facilities and high-grade stores.

My friends told me that heat for both buildings was supplied from a single boiler room which, according to them, was a showplace. I was somewhat skeptical, so they offered to take me down. We went to the basement in an automatic elevator and after threading a maze of passageways came to a stairway down to the boiler room under the playground. I found a well-lighted, clean and neatly arranged room containing three oil-fired units. Mr. Ludwig, the chief engineer, was ready to answer my many questions.

We started with the 3-drum bent-tube Keeler boilers containing 3,600 sq.ft. of heating surface, designed for 160 lb. pressure but operated at 60 to 70 lb. Baffling is arranged for three main passes, but additional staggered baffles on the 5th, 8th and 11th row of tubes makes the flue gas zigzag through the first bank of tubes. A single 72-in. steel stack 176 ft. high above the boiler-room floor provides natural draft.

The furnaces are designed for oil firing, with three Bethlehem-Dahl burners per boiler arranged as in Fig. 7. Enclosures are built around the two bottom burners, which are 2 ft. 4 in. above the furnace floor so that they draw air for combustion through the air-cooled furnace bottom, built up of old 3¼-in. boiler tubes running front to back. Tubes are laid on 1-in.

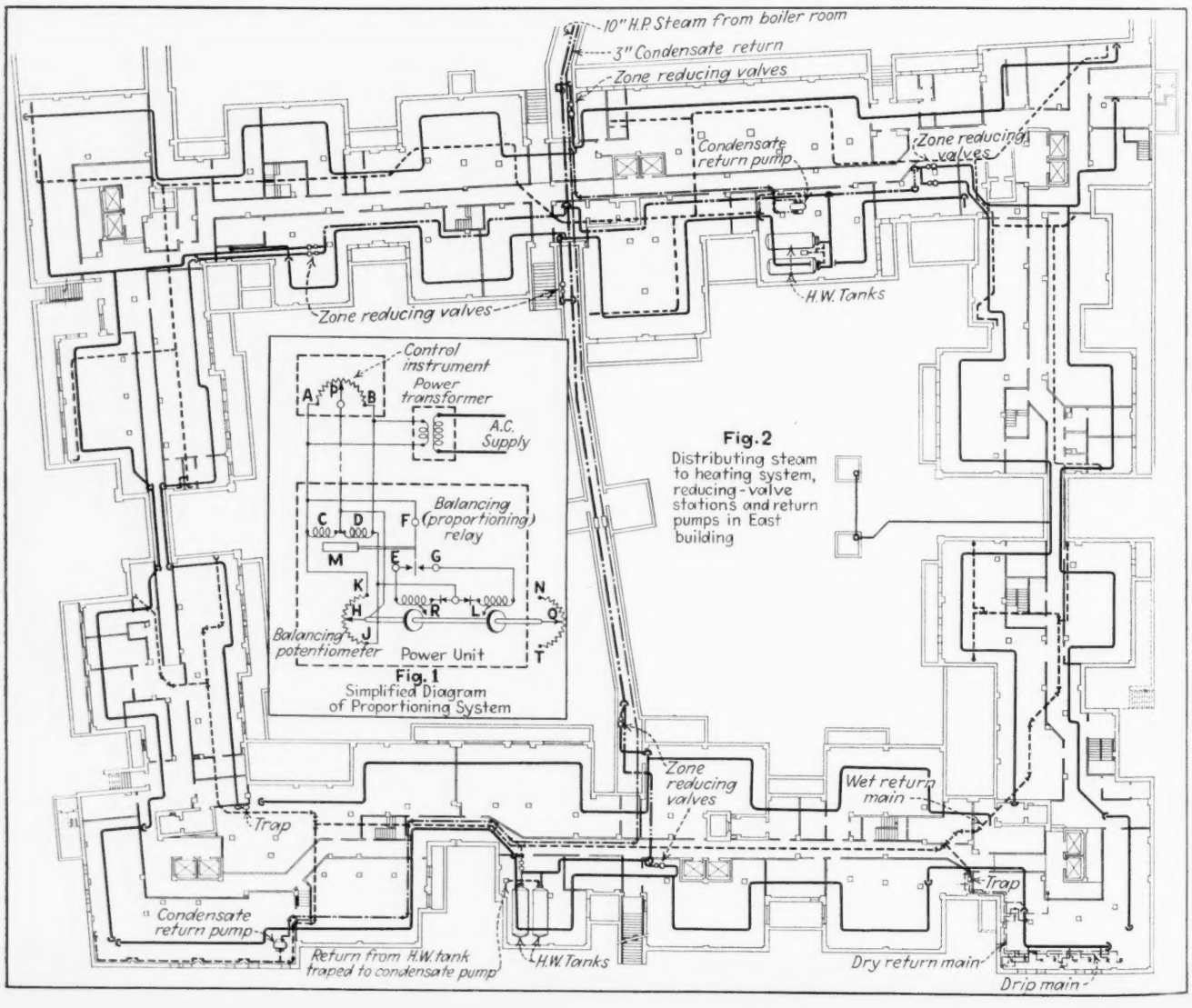


Fig. 1 Simplified Diagram of Proportioning System

Fig. 2 Distributing steam to heating system, reducing-valve stations and return pumps in East building

VILLAGE

Fig. 3—The East building at Knickerbocker Village

By R. B. Purdy
Associate Editor

magnesia block insulation and covered by ¼-in. millboard, 2 in. of Sil-O-Cel and two courses of firebrick laid flat. These precautions were necessary to protect the waterproofed concrete floor, which is below ground-water level.

Bunker C oil was chosen as fuel. It could be obtained at 3 cents a gallon, which is less than the cost of its coal equivalent in this locality. Less labor, general cleanliness and absence of ash and its removal cost also influenced the choice of fuel. During the summer, the only steam required is for heating water, and this low load could be carried more economically with oil and without installing a separate summer boiler.

Oil is stored in two 20,000-gal. tanks in concrete pits next to the boiler-room wall and kept at 110 deg. by steam coils. Two oil heaters, one above the other, are along the wall at the foot of the stairs leading to the boiler room. On a steel platform above the heaters, two pumps, one steam-driven Warren and one motor-driven Viking, circulate oil through the heaters to the burners and back to the storage tanks. A 7½-kw. electric oil heater is provided for starting up. It will heat 500 lb. of oil an hour—enough for two burners.

Heating system returns, condensate from water heaters and drips are returned by pumps to a 2,000-gal. water storage tank. Make-up direct from city main or from roof tanks is fed through a float valve to the storage tank. Three boiler-feed pumps, two electric and one steam, take their suction from the storage tank and discharge through a closed feed-water heater and Copes feed-water regulators to the boilers. Feed-water heater is supported on top of the cylindrical storage tank and will heat 48,000 lb. of water an hour from 100 to 200 deg. The steam-driven pumps exhaust to the feed water heater, but as the electric pumps are normally used feed water is usually heated with steam reduced to 2 lb.

In the firing aisle at the other end of the boiler room is a control panel for boilers and heating system. On the boiler panel are two Republic steam flow meters (one for each building) and two CO_2 recorders. Pressure and draft gages and Ess electric-eye smoke indicators are mounted on each boiler. Combustion control regulates oil pressure to burners according to steam demand and air supply by operating the boiler dampers.

Normal winter weather requires two boilers in operation during the day with an output of about 20,000 lb. of steam an hour. Actual evaporation obtained varies between 12.5 and 13 lb. of steam per pound of fuel oil. Between 13 and 14% CO_2 is maintained, with a resulting efficiency of between 75 and 76%.

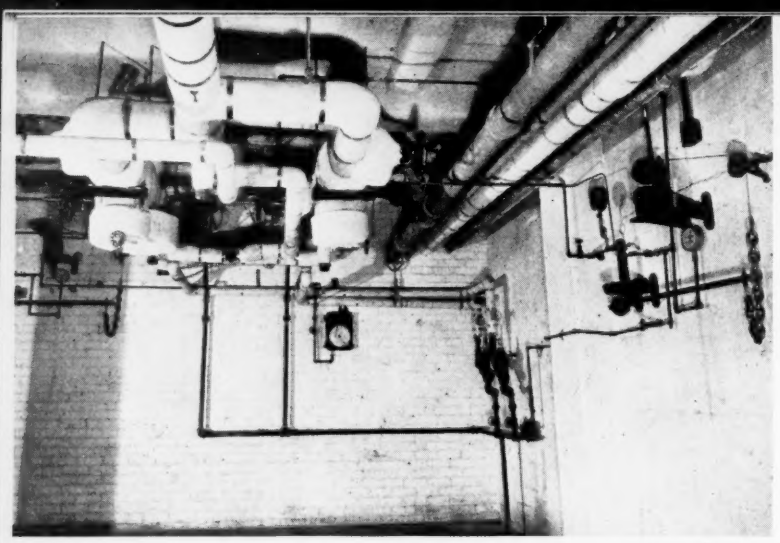
The heating system control panel caught my eye, first because it was evidently a new system of control that so far as I know has not been described, second because of the unusual arrangement of the board, shown in Fig. 8. It will be easier to understand if the heating system arrangement is first explained.

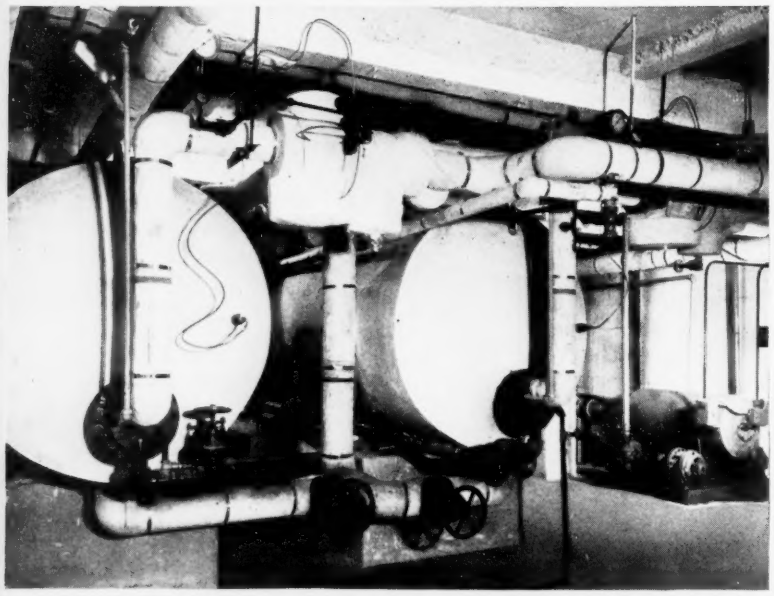
It is a zoned upfeed system with an orifice plate in the inlet to each radiator. Orifices are sized so that with 3 lb. pressure just enough steam will pass to heat completely the radiators. At lower pressures they are only partially heated. There are 4,600 radiators with a total equivalent heating surface of 128,000 sq.ft. Most of these are enclosed copper-finned radiators, though there are a number of cast-iron radiators in the basement.

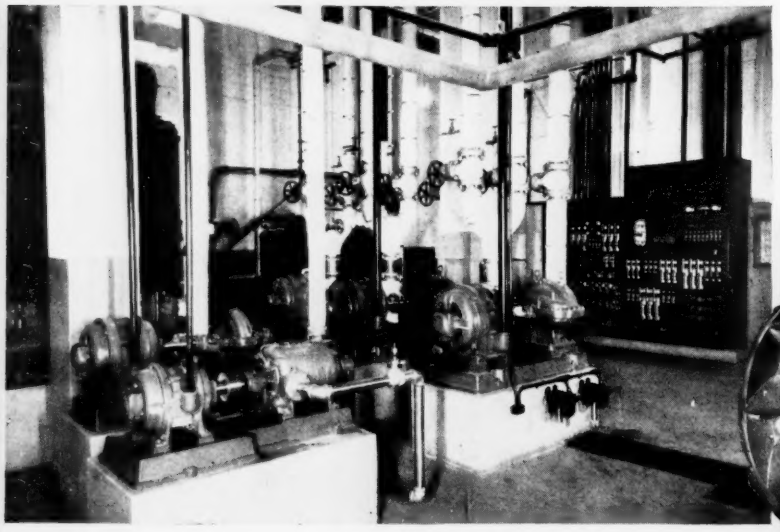
Each building has 8 zones, making 16 zones for the two buildings, all controlled from the boiler-room panel. There are N, E, S, and W zones for radiators along the outside walls of each building and corresponding zones for the walls facing the court.

Chromium-plated metal strips on the control board outline the two buildings. Zone divisions are marked by red strips and each zone is numbered to correspond with numbers on individual zone controls. This gives the engineer a diagram which makes it easy for him to visualize what zones require more heat for various weather conditions.

Both temperature and wind affect heat loss from a building, and the Spence Engineering control is arranged to supply steam in accord with both variables. The control is set manually for outside temperature conditions and automatically for wind velocity and direction. A combination of Minneapolis-Honeywell proportioning motors is used to operate a cam in direct proportion to temperature and wind changes. The cam is shaped to load a pressure-reducing valve according to the square law, thus giving equal changes in steam







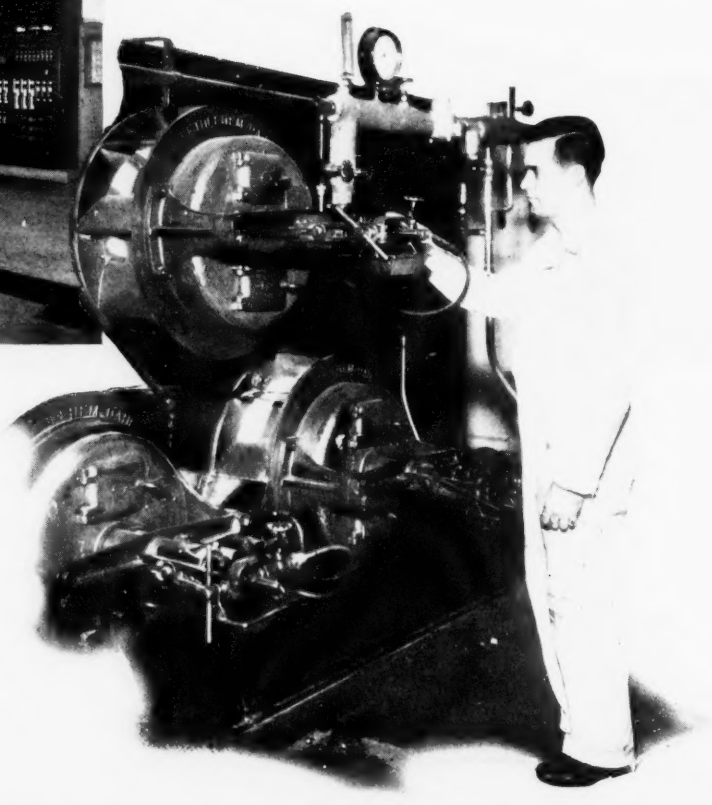


Fig. 4 (Top)—Two of the reducing-valve stations. Fig. 5 (Center)—Two water heaters, with condensate-return pump at right. Fig. 6 (Above)—Boiler-feed (left) and house pumps and the electric switchboard (right). Fig. 7 (Right)—Three oil burners are used on each boiler

flow for equal changes in temperature and wind velocity. Fig. 4 shows two of these reducing-valve stations. On the side wall can be seen one of the pilot valves. The cam controls the length of chain supported by the pilot-valve lever arm, which in turn controls the pressure-reducing valve.

Mr. Ludwig explained the proportioning system to me with the aid of the simplified diagram, Fig. 1. First assume sliding contacts of all units are in the center position shown. Under these circumstances resistances *AP, PB, JH* and *HK* are all equal, and current flowing in coil *C* is equivalent to that flowing in coil *D*. Armature *M* will then be acted on by equal magnetic forces from coils *C* and *D*, and blade *F* will be held in the gap between contacts *E* and *G*. The motor unit will be at rest, with armature *M* in what corresponds to the center position. Any deflection of the controlling instrument will cause a variation in the ratio. Assuming that this moves blade *P* toward extremity *A*, there will be an immediate unbalance in the electrical system, as resistance *AP* will be less than *PB*. The net result is that more current will flow in the circuit of coil *D* than in that of coil *C*. Armature *M* will then move under coil *D* due to its increased magnetic effect, and blade *F* will make contact at post *G*. With this circuit closed, rotor marked *L* will be energized. As the power unit revolves, the associated balancing potentiometer sliding contact *H* will be moved toward the end of its resistance *J*. When the increase in resistance *HK* has overcome (balanced) the lowered resistance *AP* in the controller so that effect of *AP* and *HK* is equal to that of *PB* and *JH*, the coils *C* and *D* again will exert equal influence on armature *M*. This will cause armature *M* to move to the central position, breaking contact at *G*.

The motor unit which operates the previously mentioned cam is similar to the control just described, and is actuated by resistance *TON* placed on the shaft of the proportioning control motor. Sixteen such resist-

ances are mounted on the motor shaft of the control unit, each actuating the cam motor for one zone.

There is one control unit for temperature and one for wind velocity automatically controlled by an anemometer. Resistances *TON* on the shafts of the two control motors are interconnected to exercise approximately equal effect on the heating system. A weather vane is connected in the circuit so that the wind-velocity control affects only zones against which the wind is blowing. The anemometer is damped so that only the average velocity during half-hourly intervals affect the heating system.

For temperature control, resistance *APB* is set by hand according to outside temperatures recorded in the boiler room. The resistance is incorporated in the temperature recorder and arranged so that an alarm rings and a red light goes on when outside temperature drops below the manual setting, a green light goes on if the temperature rises above the setting.

Any individual zone may be taken off automatic control and operated manually independent of other zones. Likewise any one zone may be adjusted from the control board to receive more or less steam as required.

In back of the control board I found a time clock used to impose full 3 lb. pressure on the system every 2 hr. for about 15 min., the object being to blow out the system and so clean out condensate that may have collected in pockets.

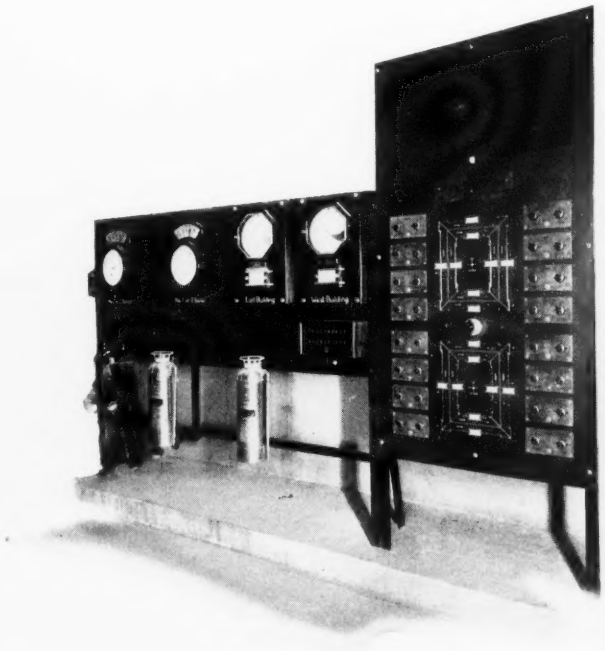
Distribution of steam to the heating system, location of reducing valve stations and return pumps is shown for the East building in Fig. 2. Although not identical, distribution in the West building is similar. Each boiler delivers steam to a 12-in. header hung from the boiler room ceiling, as in Fig. 9. This header divides into two 10-in. lines that feed to the East and West buildings at boiler pressure. All high-pressure piping over $1\frac{1}{4}$ in. is welded.

Condensate is collected by a combination dry and wet return system which discharges to two duplex Economy condensate pumps, each of 60,000 sq.ft. capacity. Each pump handles the condensate from half of each building, making four pumps for the two buildings. Main wet return lines are carried in concrete trenches under the floor. Condensate from a convenient section of radiators is first connected in a dry return line, which then drops to the wet return. This arrangement avoided pocket and venting difficulties in running a long dry return main.

Riser heels are connected direct to independent drip mains without traps. The drip mains discharge through heavy-duty traps to the wet return main.

Water for domestic use is supplied to each building through two 4-in. city mains. City water pressure feeds up to the 4th floor. Above this, water is supplied from 8 roof tanks cross-connected in each building and each holding 20,000 gal., of which 3,500 gal. is for fire protection. Roof tanks are filled by three house pumps of 600-g.p.m. capacity.

Water is heated by two banks of two heaters in each building. Each heater has a storage capacity of 1,500 gal. and will heat 1,500 gal. an hr. from 40 to 180 deg. They are supplied with steam at boiler pressure, which is reduced to about 10 lb. by a combination reducing valve and thermostatic valve.



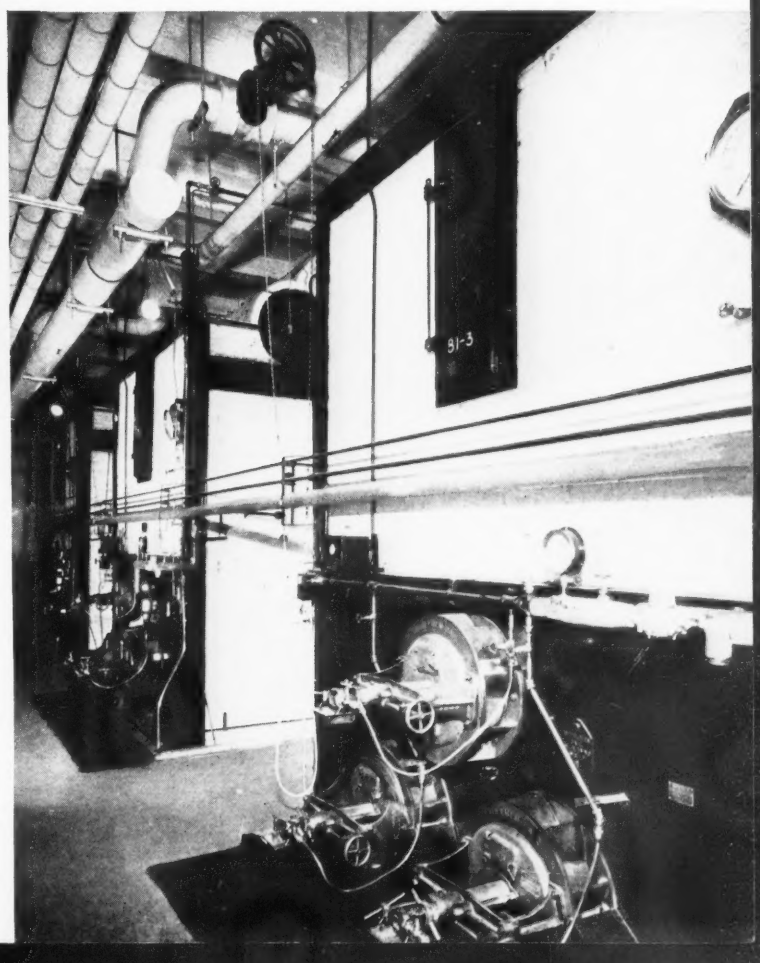


Fig. 8 (Above)—Heating system control panel at right; showing weather-compensating arrangement. Fig. 9 (Right)—The firing floor, showing the three boilers and, at upper left, the main steam header

For More than Three Years

52 WINTON-DIESEL ENGINES

HAVE BEEN IN CONTINUOUS SERVICE ON THE GREAT LAKES PIPE LINE . .

The Great Lakes Pipe Line is owned by the Great Lakes Pipe Line Company, Kansas City, Missouri. With more than 1500 miles of pipe line in service, this is the first extensive line completed for transporting gasoline exclusively. Throughout its more than three years of operation, the enterprise has proved an outstanding accomplishment in engineering refinement, completeness, and unusual operating record. The accompanying map illustrates the broad scope of the Great Lakes Pipe Line as it connects refineries in the mid-continent with distributing points in the Chicago and Great Lakes area.

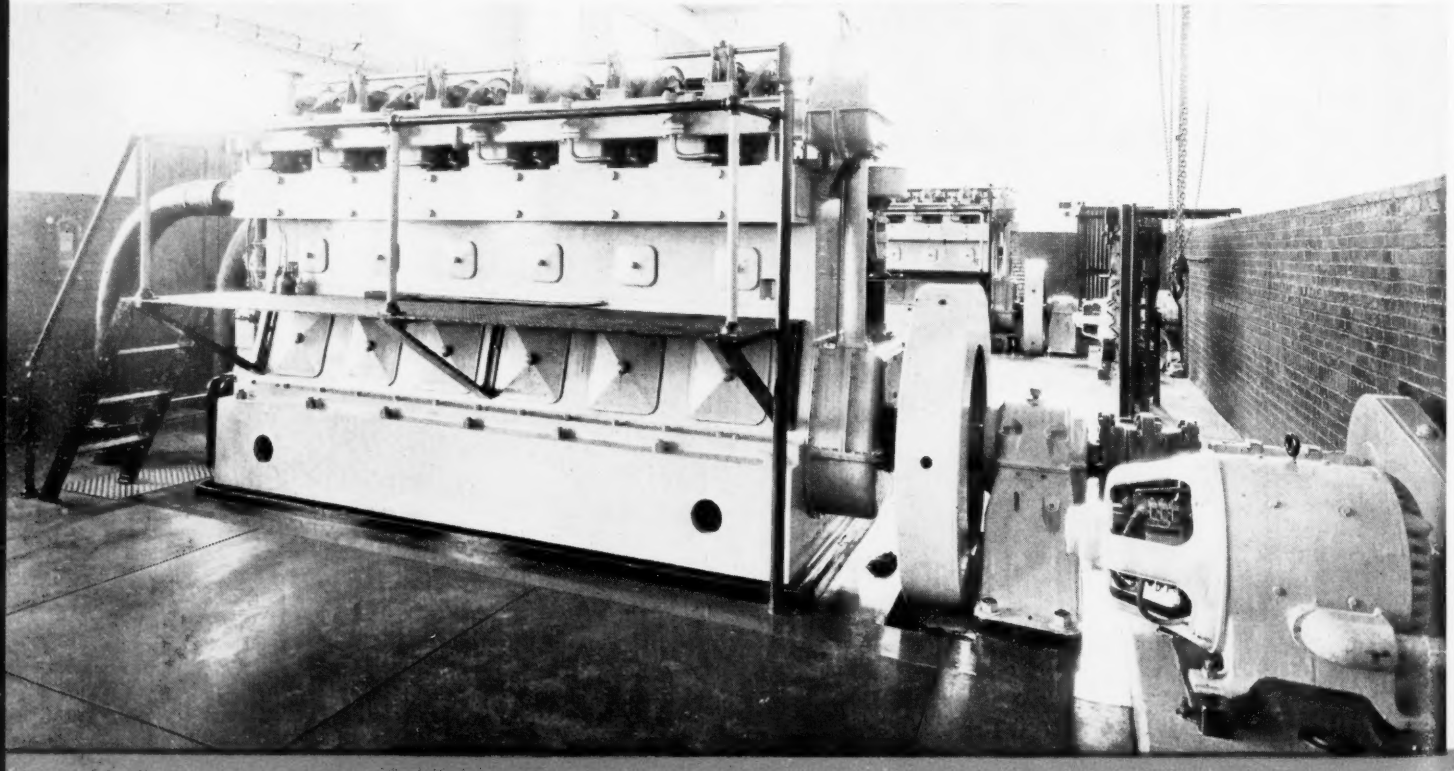
Of notable importance in the successful operation of the Great Lakes Pipe Line is the outstanding performance of 52 Winton-Diesel Engines that have been in continuous service for over three years. In every instance these Winton-Diesel Engines have demonstrated their remarkable efficiency and maintenance economy.

This successful application of Winton-Diesel Engines to pipe line service, as exemplified in the Great Lakes Pipe Line, quite logically suggests the installation of these modern engines on other lines. In their compact, simple design, rugged construction, and smooth performance, Winton-Diesel Engines provide all of the desirable features of the Diesel engine at its best—ideally suited to provide the operating economy needed in modern power installations. To facilitate the proper consideration of Winton-Diesel Engines for such service, our engineers will, upon request, be glad to supply complete information pertaining to the design and sizes of engines best suited to your particular needs.

Symbol of Economy and Dependability

WINTON ENGINE CORPORATION, Cleveland, Ohio, U. S. A.

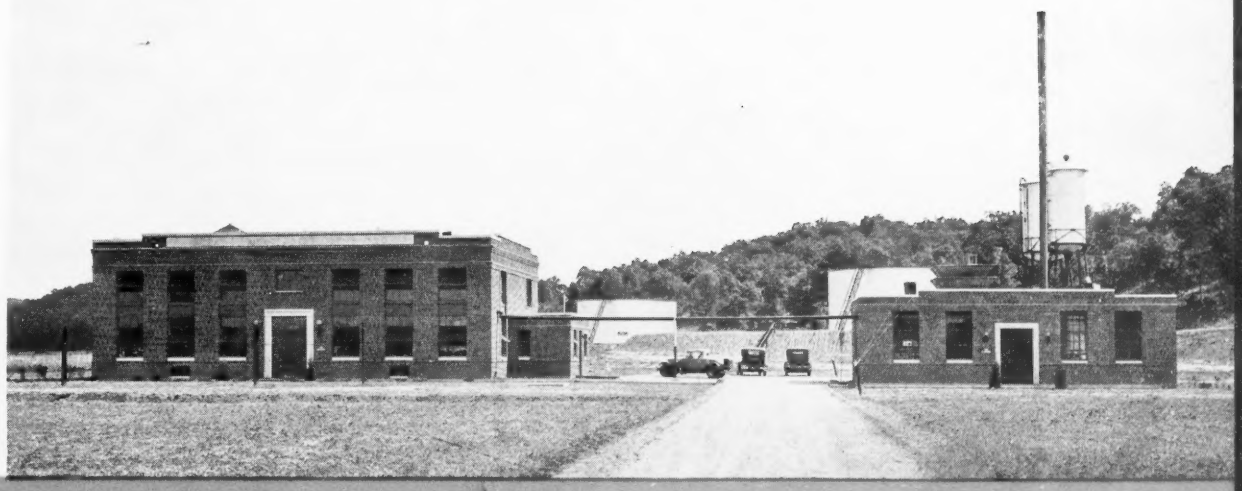
Great Lakes Pipe Line eight-inch-line engine room showing installation of two six-cylinder, 330 b.h.p. Winton-Diesel Engines



WINTON-DIESEL POWER Proves Its Economy and

Suggesting suitability of Winton - Diesel Engines for central power stations and isolated plants

Showing modern, fireproof buildings characteristic of the Great Lakes Pipe Line Stations



Dependability in Pipe Line and Industrial Service

GEARED POWER

Select most economical speeds your mechanical transmission tions, initial costs, available and speed ratio are factors

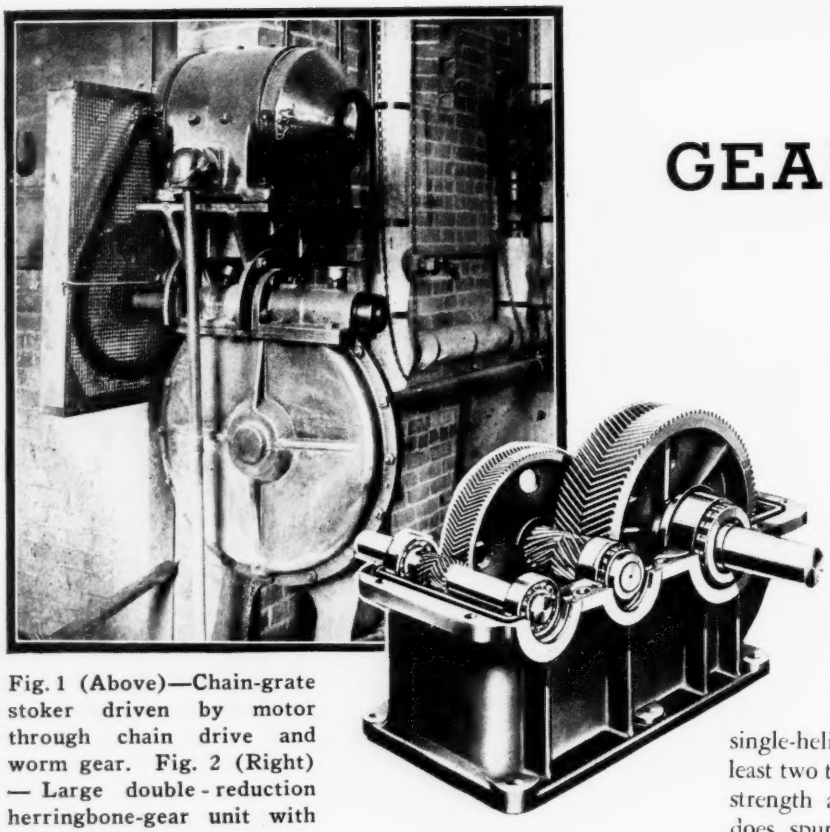


Fig. 1 (Above)—Chain-grate stoker driven by motor through chain drive and worm gear. Fig. 2 (Right) — Large double-reduction herringbone-gear unit with ball and roller bearings

FOR speed ratios up to 7:1, gear reducers compete with belts. For higher ratios, they generally have an advantage over other types of transmission equipment. Almost any desired speed ratio can be obtained with a single unit and at relatively high efficiency. Practically every conventional type of gear is used, including worm, spur, planetary, spiral, helical, herringbone, and bevel.

Worm-gear Types

Modern worm gears are built for both single and double reductions, for reductions as low as 4:1, and as high as 100:1 in a single reduction. Using two worms and two gears, speed reductions as high as 500:1 are practical. Because of low efficiencies of very high ratios, reductions above 80:1 are not generally used. With a single reduction, the input shaft is at right angles with the output shaft. Although usually arranged with the gear wheel and worm shaft horizontal, units may be had with either shaft vertical. Units are also built with the worm over the gear, Fig. 1, but the usual arrangement has the worm below. For high ratios and to obtain units with the input and output shafts parallel, double-reduction units are used. Efficiency of these units will vary with speed ratio, lubrication and other conditions; but over 98% efficiency has been attained. They are adapted to worm speeds up to 4,000 r.p.m. or higher for comparatively small power. For speeds of 1,800 r.p.m. and less, they have been built for inputs up to 250 hp.

Recent years have seen double-helical or herringbone gears, Fig. 2, come into wide use in preference to single-helical designs. Helical gearing always has at least two teeth in contact, which increases its mechanical strength and offers more resistance to breakage than does spur gearing. Although a herringbone gear is practically balanced against end thrust, it is not always preferable to a single-helical gear. Where there is end thrust on the shaft sufficient to cause a slight deflection of the gear casing, half of a herringbone gear might become unloaded and the other half overloaded, a condition which could easily cause excessive wear on one half of the gear. High-grade gears are high-carbon, chrome-nickel steel or a steel of equal quality, with the teeth specially generated to insure close precision. High-speed shaft and gear are usually integral. The slow-speed gear is made separate and keyed to its shaft in a single-reduction unit. In double-reduction units, the second-stage shaft and pinion are integral.

Ratios from 2:1 to 8:1 are standard for single-reduction units and from 8:1 to 60:1 ratios in the double-reduction arrangements. Above a ratio of 60:1, triple reductions are generally used, although singe-reduction ratios of 10:1 and double reductions up to 70:1 are built. Where high ratios are required, reductions up to 200:1 can be supplied in a single unit.

Wide Range of Capacities

They are built in a wide range of capacities in compact self-contained units. For example, a double-reduction unit with an input-shaft speed of 860 r.p.m. and an output-shaft speed of 19 r.p.m. was built for direct connection to a 250-hp. motor and mine hoist. Herringbone gears are also suitable for high-speed operation and are available for pinion speeds up to 8,500 r.p.m. and capacities of 2,500 hp. Normal arrangement of herringbone-gear speed reducers is with parallel, horizontal shafts, Fig. 2, but right-angle arrangements are available in double and triple reductions. Fig. 3 shows a double-reduction unit, the first reduc-

TRANSMISSION

for motor and load, then choose to match them. Service condi- space, atmospheric conditions in selection of type and size

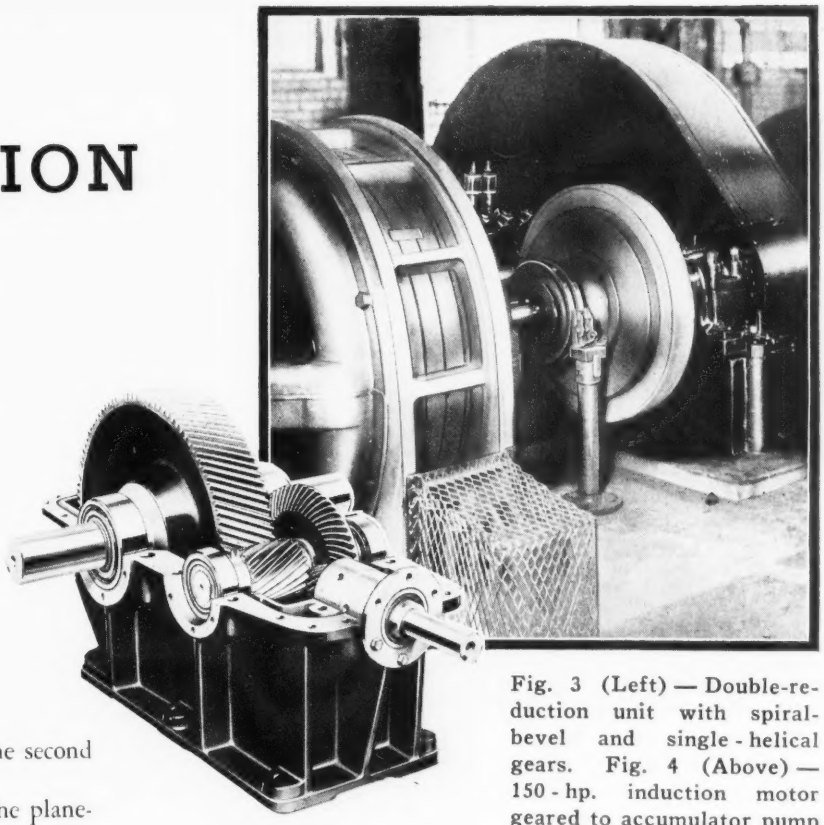


Fig. 3 (Left) — Double-reduction unit with spiral-bevel and single-helical gears. Fig. 4 (Above) — 150-hp. induction motor geared to accumulator pump through magnetic clutch

tion being made by a spiral-bevel gear and the second by a single-helical gear.

Spur-gear reducing units are generally of the planetary type, and include a pinion mounted on the input shaft. Generally three or more idler gears, set radially around the pinion, mesh with it and connect to the output shaft by a spider. These idlers mesh into a stationary internal gear that forms a raceway about which they travel. Single-reduction units are suitable for speed reductions of 3:1 to 8:1. Below 3:1 and preferably 4:1 ratios, idler speed becomes objectionably high. Speed ratios up to 500:1 are obtainable by connecting two or more units together in the same casing. For single-reduction units, input- and output-shaft axes form a straight horizontal line through the unit. In double- and triple-reduction units, by using a bevel gear for the first reduction, right-angle drives may be obtained.

Motor-reducer Units

During the last ten years there has been tremendous development in units combining motor and gear. These units are available under several names, such as gear-motor, motorized speed reducer, motorized gear reducer, and motor-reducer unit. For single-reduction ratios up to 10:1, the reduction gear is generally mounted directly on the motor. In double- and triple-reduction units, the gear case usually supports the motor. About 100 hp. is the economic limit of capacity for such units. Motor speeds of 1,750 and 3,500 are used for the smaller-sized units and any desirable output speed is attainable. With 1,800-r.p.m. motors, one manufacturer offers an output speed range of from 7,000 down to 10 r.p.m. The motorized-gear unit combines the desirable characteristic of a high-speed motor with a high-efficiency gear.

These units are light in weight, compact and of low-cost compared to a slow-speed direct-connected motor. For example, a unit combining a 5-hp., 1,800-r.p.m., induction motor and a speed reducer to give an output speed of 240 r.p.m. costs about 30%, and weighs one-sixth, as much as a motor designed to operate at 290 r.p.m. These units not only have the advantage of low cost and compactness but have simplified alignment of motor and gear units with the driven-machine shaft. One unit has to be kept in alignment instead of two, and couplings have been reduced from two to one.

No Standard Basis

Gear-reducer units unfortunately are not rated on a standard basis, therefore, great care must be used in selecting them. Some manufacturers build their gears on a basis of 24-hr. service, while others recommend a somewhat lower-capacity gear for 8-hr. per day service than for 24-hr. service. Operation under 100% momentary overload and 25% continuous overload are provided in some designs. This makes them good for practically any service within their horsepower rating. For other designs service factors ranging from 1 to 2, depending on the kind of load to be driven, are applied to the motor rating when selecting the gear unit. Much can be said for both methods of rating gear units, but since different standards exist, mechanical-power-transmission engineers should have them clearly in mind, and when in doubt err on the safe side. An oversized gear may cost more and require greater space than one of correct rating, but it will pay its way in continuous service and low maintenance costs when an undersized unit will be a source of trouble and expense.

Refrigeration to Lower Wet-Bulb Temperature

TONS REFRIGERATION PER 100 LB. DRY AIR PER MINUTE

Final Wet-Bulb Temperature, Deg. F.	Initial Wet-Bulb Temperature, Deg. F.															
	80	78	76	74	72	70	68	66	64	62	60	58	56	54	52	50
75	2.5	1.5	0.5													
74	2.95	1.95	0.95	0.0												
73	3.4	2.4	1.4	0.45												
72	3.9	2.9	1.9	0.95	0.0											
71	4.3	3.3	2.3	1.35	0.4											
70	4.7	3.6	2.6	1.65	0.8	0.0										
69	5.1	4.1	3.1	2.15	1.2	0.4										
68	5.5	4.5	3.5	2.55	1.6	0.8	0.0									
67	5.95	4.95	3.95	3.0	2.05	1.25	0.45									
66	6.4	5.4	4.4	3.45	2.5	1.7	0.9	0.0								
65	6.75	5.75	4.75	3.8	2.85	2.05	1.25	0.35								
64	7.1	6.1	5.1	4.15	3.2	2.4	1.6	0.7	0.0							
63	7.5	6.5	5.5	4.55	3.6	2.8	2.0	1.1	0.4							
62	7.85	6.85	5.85	4.90	3.95	3.15	2.35	1.45	0.75	0.0						
61	8.15	7.15	6.15	5.20	4.25	3.45	2.65	1.75	1.05	0.3						
60	8.5	7.5	6.5	5.55	4.6	3.8	3.0	2.1	1.4	0.65	0.0					
59	8.9	7.9	6.9	5.95	5.0	4.2	3.4	2.5	1.8	1.05	0.4					
58	9.2	8.2	7.2	6.25	5.3	4.5	3.7	2.8	2.1	1.35	0.7	0.0				
57	9.5	8.5	7.5	6.55	5.6	4.8	4.0	3.1	2.4	1.65	1.0	0.3				
56	9.8	8.8	7.8	6.85	5.9	5.1	4.3	3.4	2.7	1.95	1.3	0.6	0.0			
55	10.1	9.1	8.1	7.15	6.2	5.4	4.6	3.7	3.0	2.25	1.6	0.9	0.3			
54	10.4	9.4	8.4	7.45	6.5	5.7	4.9	4.0	3.3	2.55	1.9	1.2	0.6	0.0		
53	10.7	9.7	8.7	7.75	6.8	6.0	5.2	4.3	3.6	2.85	2.2	1.5	0.9	0.3		
52	11.0	10.0	9.0	8.05	7.1	6.3	5.5	4.6	3.9	3.15	2.5	1.8	1.2	0.6	0.0	
51	11.3	10.3	9.3	8.35	7.4	6.6	5.8	4.9	4.2	3.45	2.8	2.1	1.5	0.9	0.3	
50	11.6	10.6	9.6	8.65	7.7	6.9	6.1	5.2	4.5	3.75	3.1	2.4	1.8	1.2	0.6	0.0
49	11.9	10.9	9.9	8.95	8.0	7.2	6.4	5.5	4.8	4.05	3.4	2.7	2.1	1.5	0.9	0.3
48	12.15	11.15	10.15	9.20	8.25	7.45	6.65	5.75	5.05	4.3	3.65	2.95	2.35	1.75	1.15	0.55
47	12.4	11.4	10.4	9.45	8.5	7.70	6.9	6.0	5.3	4.55	3.9	3.2	2.6	2.0	1.4	0.8
46	12.8	11.8	10.8	9.85	8.9	8.1	7.3	6.4	5.7	4.95	4.3	3.6	3.0	2.4	1.8	1.2
45	12.95	11.95	10.95	10.00	9.05	8.25	7.45	6.55	5.85	5.10	4.45	3.75	3.15	2.55	1.95	1.35
44	13.2	12.1	11.1	10.15	9.2	8.4	7.6	6.7	6.0	5.25	4.6	3.9	3.3	2.7	2.1	1.5
43	13.45	12.45	11.45	10.50	9.55	8.75	7.95	7.05	6.35	5.6	4.95	4.25	3.65	3.05	2.45	1.85
42	13.7	12.7	11.7	10.75	9.8	9.0	8.2	7.3	6.6	5.85	5.2	4.5	3.9	3.3	2.7	2.1
41	13.9	12.9	11.9	10.95	10.0	9.2	8.4	7.5	6.8	6.05	5.4	4.7	4.1	3.5	2.9	2.3
40	14.1	13.1	12.1	11.15	10.2	9.4	8.6	7.7	7.0	6.25	5.6	4.9	4.3	3.7	3.1	2.5
39	14.3	13.3	12.3	11.35	10.4	9.6	8.8	7.9	7.2	6.45	5.8	5.1	4.5	3.9	3.3	2.7
38	14.55	13.55	12.55	11.6	10.65	9.85	9.05	8.15	7.45	6.7	6.05	5.35	4.75	4.15	3.55	2.95
37	14.75	13.75	12.75	11.8	10.85	10.05	9.25	8.35	7.65	6.9	6.25	5.55	4.95	4.35	3.75	3.15
36	15.0	14.0	13.0	12.05	11.1	10.3	9.5	8.6	7.9	7.15	6.5	5.8	5.2	4.6	4.0	3.4
35	15.2	14.2	13.2	12.25	11.3	10.5	9.7	8.8	8.1	7.35	6.7	6.0	5.4	4.8	4.2	3.6

THIS chart is particularly useful in solving air washer problems. For example, assume an air washer is installed to handle 10,000 c.f.m. of air at 90 deg. dry-bulb and 70 deg. wet-bulb. How much refrigeration must be provided in order that the air leaving the washer will have a wet-bulb temperature of 50 deg.? At 70 deg. dry-bulb, 1 lb. of air has a volume of 13.86 cu.ft. 10,000 c.f.m. of air contains 721 lb. of dry air a minute. From the chart, 6.9 tons of refrigeration are required per 100 lb. of dry air per min. to reduce the wet-bulb temperature from 70 to 50 deg. For 721 lb. of dry air, 6.9x7.21 = 49.8 tons of refrigeration required.

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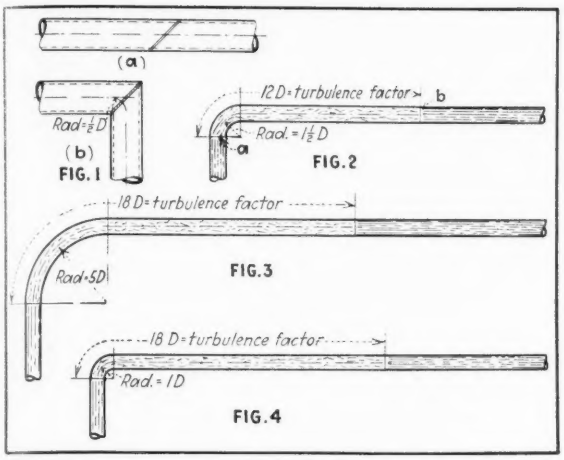


How Large a Radius on PIPE BENDS?

By C. C. Hermann
Waterloo, Iowa

"WHAT! No 2½-in. elbow in stock! Bill, bring up the welding outfit and we'll make one. I've heard about those welded pipe jobs. Now is our chance to try one."

His finished job looked something like Fig. 1. The job is interesting in our analysis of pipe friction and the turbulence created within the pipe by sudden turns.

The fitting was made by cutting a 45-deg. end on the pipe as at *a*, then welding the short end to the beveled end as at *b*. The radius of the turn was ½ *D* or 1.4375 in. The turbulence factor was about 30 *D*, whereas with the very poorest commercial fitting this factor would have been only about 18 *D*. The net result was to increase the friction through the fitting 66⅔%. If the radius of the elbow had been increased to 3, the turbulence factor would have been 9 *D* and friction 30% less.

If one could go through plants and cut pipeline fitting friction loss 30% a tremendous saving could be shown. And that is about what could be done! Without exception many cases of waste could be found not only in friction but in piping declared obselete due to insufficient capacity. Many pipe systems are dismantled because of being out-grown and consequently replaced by pipe of larger dimensions, whereas with some care in changing or eliminating fittings, turns and bends, the line could be saved. Sometimes even an investment in a new larger pump can be avoided.

Old Pipe for New Trouble

Not long ago I saw a pipeline being put in for handling untreated river water. The fellow bossing the job was using a lot of old rusty pipe. He was apparently happy, not knowing that he was going to pay for that rusty pipe over and over again. The old tuberculated pipe was going to multiply his pressure drop through the line by at least 2½ times that in a good grade of new pipe.

Some men think that if pressure drop is reduced by use of a turbulence factor of 2½, then a factor of 5 or 7 will reduce it still more. This is erroneous. To go above R/D = 3 is to increase the length of the turbulence area within the pipe. This is more clearly illustrated by reference to Figs. 2 and 3. In Fig. 2 is shown $R/D = 1\frac{1}{2}$. The liquid leaves straight-line flow conditions at *a*, is turbulent around the bend and continues to be more or less turbulent until *b* is reached, which is approximately 12 *D*. Beyond this point the liquid assumes a condition of straight-line flow. In Fig. 3 is shown the same kind of bend using an *R/D* ratio of 5. The turbulence factor in this case is near 18 *D*. In Fig. 4 is shown the same type of turn having an *R/D* ratio of 1 and results in a turbulence factor of about the same magnitude as that shown in Fig. 3. Obviously the radius could be made ever so large but turbulence would continue to exist until the pipe actually straightened out so that all particles of the liquid would be flowing in straight lines.

Keep Pressure Drop Down

Commercial screw fittings, if one were to examine the screw connection between the fitting and the pipe, would disclose conditions which tend to increase turbulence in the line. Also most commercial screw fittings have a low *R/D* ratio, except in special classes. But we cannot even insure lower pressure drop in all types of welds. However, where commercial welding fittings are used a larger measure of success will obtain.

When the fitting is tack-welded to the end of the pipe, care must be exercised to see that the ends match exactly or the joint will be just as resistant to flow as any screw fitting could possibly be. The end of the pipe and the fitting must be properly beveled or scarfed to an angle of 45 deg. and preferably held together in a jig while welded.

Of the different types of welding, I prefer the electric arc in pipe work. Using coated rod, the welder should run about 1 in. per min. The actual welding of a 3-in. pipe should not exceed one minute and including the preparation should not take longer than the screw joint.

Regular commercial bends adapted to welding are designed with a radius of 1½ times the diameter of the pipe (nominal). However, they may be obtained with a ratio of from 1 to 4. The ideal ratio to use is 2½, that is, 2½ times the nominal pipe diameter.

SUMMER WEATHER IN WINTER

When Heaters Help Condition Air

By R. B. Purdy
Associate Editor

AIR-CONDITIONING systems must maintain proper temperature and humidity in winter as well as summer. In winter, heating and humidification are required; in summer, cooling and dehumidification. Usually a direct system of heating is installed to provide all of the heat necessary to take care of the heat loss from the building, and it is only necessary for the conditioning system to increase humidity of the air and to supply it at the desired room temperature.

When air conditioning is installed for process control in a factory, humidity conditions must be maintained according to process requirements in winter as in summer. But for comfort conditioning, relative humidity in winter must often be carried lower than in summer to avoid window condensation. With average winter temperature (say 32 deg.) a relative humidity of 35% can be carried without encountering objectionable window condensation. Higher humidity will cause trouble.

If 72 deg. dry bulb and a relative humidity of 35% is desired, air must be supplied to the room at these conditions. This may be accomplished in several ways, (1) the spray water in the air washer may be heated to give the desired humidity, tempering coils installed ahead of the washer to heat the cold fresh air above the freezing temperature and reheating coils installed to control final dry-bulb temperature; (2) controlling humidity by raising the temperature of the incoming air so that when saturated with recirculated water in the air washer it will have the desired dew-point, then reheating; and (3) controlling humidity by controlling the ratio of recirculated and fresh air entering the air washer.

Performance of Finned-Tube Heater

Inlet Temp. Deg. F.	Rows of Tubes Deep	Velocity of Air Through Face Area, ft. per min.[1] 300 Temp.	300 Cond.*	400 Temp.	400 Cond.	500 Temp.	500 Cond.	600 Temp.	600 Cond.	700 Temp.	700 Cond.	800 Temp.	800 Cond.
−10	1	32	1.6	30	2.0	27	2.3	24	2.6	22	2.8	20	3.0
	2	65.5	1.5	62	1.8	57	2.2	52.5	2.4	50	2.7	46.5	2.9
	3	93.4	1.3	88.5	1.7	82	1.9	77	2.2	73.3	2.5	69	2.7
0	1	40	1.5	38	1.9	35	2.2	32.4	2.4	30.4	2.7	29	2.9
	2	72.6	1.4	69	1.8	64	2.1	60	2.3	57	2.6	54	2.8
	3	99	1.3	94	1.6	88	1.9	83	2.1	79	2.4	75	2.5
10	1	47.5	1.4	46.3	1.8	43.5	2.1	40.7	2.3	39.3	2.6	38	2.8
	2	78.7	1.3	75.3	1.7	71.2	1.9	67	2.2	64.4	2.4	61.6	2.7
	3	104	1.2	99.2	1.5	93.8	1.8	89.2	2.0	85.2	2.2	82	2.4
20	1	56	1.4	54.2	1.7	52	2.0	49	2.2	47	2.45	46.4	2.64
	2	85.3	1.3	82	1.6	78	1.9	74.3	2.1	71.5	2.3	69	2.5
	3	109.4	1.1	104.6	1.4	99.5	1.7	95.5	1.9	91.3	2.1	88	2.3
30	1	63.6	1.3	62	1.6	60	1.9	58	2.1	56.5	2.3	55	2.5
	2	91.7	1.2	85.5	1.5	84.6	1.76	81.6	2.0	78.6	2.2	75.7	2.4
	3	114.3	1.1	109.6	1.4	105.4	1.6	101.5	1.8	97.5	2.0	94	2.2
40	1	72.3	1.2	70.4	1.5	68.3	1.8	66.5	2.0	64.5	2.1	63.5	2.4
	2	99	1.1	95	1.4	91.5	1.7	88.6	1.9	85.5	2.0	83.2	2.2
	3	120	1.0	115.3	1.3	111.3	1.5	107.6	1.7	103.6	1.9	100.4	2.1

*Condensate, Lb. per Hr. per Lineal Foot of Tube.
[1]Velocity Based on 70-Deg. Air.

Performance of Vento Heater

Inlet Air Temp. Deg. F.	Sections Deep	Velocity of Air Through Free Area, ft. per min. 600 Temp.	600 Cond.*	800 Temp.	800 Cond.	1,000 Temp.	1,000 Cond.	1,200 Temp.	1,200 Cond.	1,400 Temp.	1,400 Cond.	1,600 Temp.	1,600 Cond.
0	1	34	1.69	...	....	...	....	...	....	...	....	..	....
	2	69	1.52	62	1.85	56	2.12	51	2.35	47	2.56	44	2.77
	3	96	1.36	87	1.66	80	1.92	75	2.18	70	2.39	66	2.60
10	1	43	1.65	38	1.95	35	2.4	32	2.46	...	....	..	....
	2	75	1.44	68	1.74	62	1.99	58	2.23	54	2.42	51	2.62
	3	101	1.30	93	1.59	86	1.84	81	2.08	76	2.27	72	2.46
20	1	58	1.46	54	1.75	51	1.99	49	2.23	47	2.42	45	2.56
	2	87	1.29	81	1.57	76	1.80	72	2.0	69	2.20	66	2.36
	3	110	1.15	103	1.42	97	1.65	92	1.85	88	2.06	85	2.22
30	1	66	1.39	62	1.64	60	1.92	58	2.17	56	2.33	54	2.46
	2	93	1.21	87	1.46	83	1.70	79	1.89	76	2.06	73	2.21
	3	115	1.09	108	1.33	103	1.56	98	1.75	94	1.91	91	2.08
40	1	74	1.31	70	1.54	68	1.80	66	2.0	64	2.16	62	2.26
	2	100	1.15	94	1.39	90	1.60	86	1.77	83	1.93	81	2.10
	3	121	1.04	114	1.26	109	1.47	104	1.64	100	1.79	97	1.95

*Condensate, Lb. per Hr. per Sq. Ft.

Resistance is Important

The reheater and tempering coils required are either finned-tube or cast-iron vento heaters, of which those illustrated are typical. Resistance to air flow through the heaters is of considerable importance, and in general should not be more than 40% of the total system resistance. Air velocity through the face area for finned-tube heaters should be between 500 and 700 ft. per min. and from 1,000 to 1,400 ft. per min. through net free area for vento heaters. The curve shows how air resistance of finned-tube and vento heaters goes up with velocity, and the table gives their heating performance.

In case (1), where humidity is controlled by heating the air-washer water, the temperature coil need only have enough capacity to heat the entering air to 35 deg. during the coldest weather. If temperatures below zero are not encountered, one row of finned tubes is sufficient, but for lower temperatures two rows may be required. The tempering coil heater is usually arranged for thermostat control, which turns on the steam when the entering temperature drops below freezing.

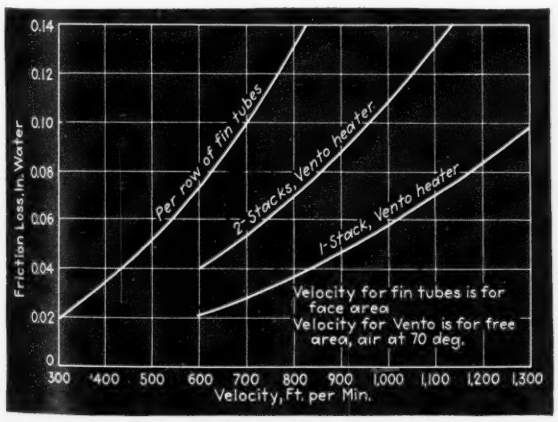
When humidity is controlled by heating the air before it enters the air washer instead of heating the water, two or three banks of heaters are usually installed—a tempering coil controlled as above to heat

the air to 35 deg. and the others to heat to the temperature required for the desired humidity. The temperature required for a given humidity is easily found from the psychometric chart by the method outlined in the article on "Humidity" in the February number.* When, for example, a dewpoint of 42 deg. in air leaving the washer is required and the entering outside air is at zero, the second bank will have to heat to a final temperature of 67 deg. Heating elements installed must have capacity to take care of the coldest weather, and when steam is turned on they heat completely, so it is necessary to provide a bypass and mix unheated air with heated air to obtain close control of temperature. A damper in the bypass is usually provided with thermostatic control to avoid the necessity for manual regulation.

When recirculated air is permitted, both tempering and heating coils may be omitted ahead of the air washer. The proportion of warm and humid return air to the dry and cold fresh air admitted can be controlled by dampers and thermostat to give the necessary dewpoint leaving the air washer. With zero outside temperature, 25% fresh air and 75% recirculated air will result in a dewpoint of about 45 deg.

Reheaters after the air washer must heat the saturated air up to the room temperature, a temperature rise usually between 25 to 35 deg. requiring 450 to 630 B.t.u. per 1,000 c.f.m. of air supplied. With low velocity, only one row of vento or finned-tube heaters is necessary. A bypass to permit temperature control is usually provided.

Steam supply piping should be designed for a velocity of 6,000 ft. per min., and return lines for 5



Resistance of heaters to air flow

to 8 ft. per min. Either combination float-and-thermostat traps or a thermostat-operated air vent and a float trap should be used in the return line. Separate traps should be provided for each heater. Traps should have sufficient capacity to take the sudden load that comes when a heater is turned on. Heaters should be placed so they will drain properly to the condensate outlet.

For heating the air-washer water, two types of heaters are in use, closed type and injector type. In the injector type, steam is mixed directly with the water. It is the cheaper type but may give the water in the air washer a characteristic steam odor that may be disagreeable in the case of building air conditioning. With closed heaters there is little chance of steam odor getting into the water.

* No. 2 in the series of which this is No. 6.

Welded Penstocks Used for 5,742 Ft. Static Head

By R. W. Miller
Engineer, Freiberg, Germany

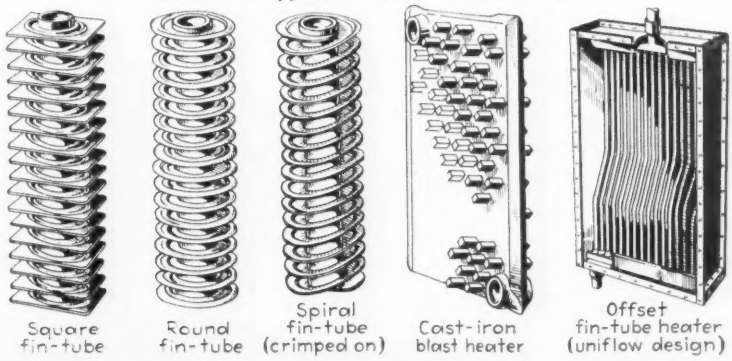
DIXENCE power station, Switzerland, will utilize a gross head of 5,742 ft. in a single stage, the world's highest. Dixence River has been dammed at Dix Valley outlet, to 7,371 ft. above sea level, forming a reservoir 24 mi. long with 1.5-billion cu.ft. storage capacity. From it water is led to a surge chamber through a 7.5-mile circular tunnel 7.4 ft. in diameter. Beginning at the surge chamber, the penstock for 1,310 ft. is a single pipe line 6.56 ft. in diameter; then it branches into two, each 18,000 ft. long.

Except for its lower ends, the penstock is in the open, supported on concrete piers. Because of its large dimensions the Y section had to be assembled and welded on the job. Anchor piers are provided at intervals, with expansion joints between. The penstocks terminate in distributor headers near the plant at elevation 1,615 ft. At their Y ends the two penstocks are 56 in. in diameter and taper to 38.5 in. at the power house. This gives a full-load water velocity of 10.5 ft. at the Y and 22.3 ft. at the distributors.

For static pressures up to about 250 lb. per sq.in. plain electric-welded pipe is used. Sections were welded together in place, and each of the 1,800 welded joints was tested to 5% above the full static pressure that will exist. Each joint is reinforced by a shrunk-on band. Completed penstocks will be subjected to shock pressures 20% above maximum static pressure, applied by control of the turtine nozzle.

The complete plant will have five units installed, each comprising a 42,500-hp. double-overhung pelton wheel directly connected to a generator. Under full load the wheels will take 300 sec.-ft. of water and the generators will deliver 133,250 kw. From the power house the water discharges into the Rhone River through a short tailrace.

Common Types of Heater Elements



HOW TO BURN LIGNITE

By Edward Green
Varsity View, Manitoba

ALTHOUGH lignite is generally recognized as an efficient fuel for steam generation, certain limitations regarding its use have caused a great deal of misunderstanding among operating engineers. The fuel itself is not to blame.

Coal of any kind, insofar as the power engineer is concerned, is nothing more than a heat-producing element. Certain grades of coal contain more heat units than do others, and there is neither guide nor guaranty that the ultimate consumer will make good use of the heat units when the fuel is being burned under his boilers. That one fuel contains more heat does not prove it is better.

And so, no matter what the quality of coal may be, if the equipment for burning and recovering its heat is not designed for the purpose and properly handled there will be waste and dissatisfaction. High- or low-grade coals have their own peculiarities, and lignite is no exception. This is overlooked at times, and attempts are made to burn it in plants never designed for such an operation. The result—much trouble, no steam, and a black mark against lignite.

Lignite coal has a high moisture content. There is also considerable shrinkage during transit. Heat per pound seldom exceeds 8,000 B.t.u. For these reasons alone it is not practical to burn this fuel in power plants if the rail haul exceeds 300 mi. High freight rates more than offset any advantages gained from its use. As a specific instance let us discuss a large heating company operating in Winnipeg, Manitoba.

This company has several plants, but one of them is designed to burn only lignite. This plant manufactures steam at a fuel cost of approximately 30 cents per thousand pounds, while the bituminous burning plants have a charge of 39 cents per thousand. Thus we find a 9-cent difference in the cost of evaporation. Lignite coal, on the track, at the plant, runs between $3.40 and $3.90 a ton, but the bituminous coal costs approximately $7 a ton at the plant. For $3.90, 13,000 lb. of steam is evaporated as against 18,000 lb. evaporated at a cost of $7. This is scarcely a creditable balance, but considering extra cost of handling lignite a slight price increase would be disastrous.

No Arches With Lignite

From this it might be said that freight rates are a ruling factor. They are to a certain extent, but if the fuel were obtained for 10 cents a ton it would be a dead loss if proper means were not provided to burn it.

In the first place, the furnace should have considerable volume. Under no conditions should the boiler, if an H.R.T., be closer to the grate than $1\frac{1}{3}$ times its diameter. On a 72-in. boiler there should be 7 ft. between the highest part of the grate and the bottom plates of the boiler. A large expansion chamber is also necessary. Although wing walls and complicated ignition arches are highly touted, they are of little value in a setting for this fuel. If a change is being made and it is found impossible to raise the boiler above the grate, a Dutch oven will often solve the problem. In some cases ignition arches have been sprung across the bridge wall in an effort to promote combustion. While they are all right in burning other fuels, they are a hindrance to lignite.

Non-sifting grates with at least a 50% air opening are required. These should be of the dump type, and if the fire is kept thin there will be no trouble. 3-5 in. is sufficient thickness. When this depth is reached the fire should be dumped at once and new coal spread on the grate. When burning lignite, ash "flakes off" in fluffy particles, and as long as it is undisturbed there will be no clinkers. For this reason a poker should never be used, and under no consideration should the fuel bed be disturbed.

Lignite *can not* be successfully burned without artificial draft. A great deal more air is required with this fuel, and regardless of stack heights it can not be secured without mechanical means. Automatic draft control, while ideal in some cases, is not practical with lignite. Fuel itself is slow on ignition, and fluctuations can not be taken care of satisfactorily, except by hand.

Good Soot Blowers Needed

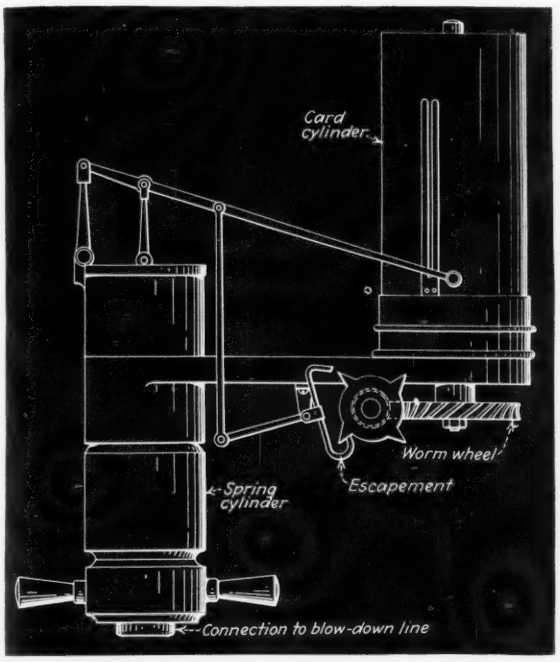
Consideration should be given to installation of good soot blowers. Without these, boiler efficiency will fall soon after the fire is started. This is due to the light, fluffy ash being carried into the passes and unless soot is blown at least four times during a 24-hr. run, the passes will quickly fill with ash.

While the overfeed principle gives good results, it is not absolutely essential. Many installations have been made of late where underfeed stokers have fired lignite, and while efficiency obtained was good, it was further increased by the addition of bituminous coal. A mixture of two parts bituminous and three parts lignite gave excellent performance. Fly ash decreased and no trouble was experienced in clinkering. These proportions are not fixed.

A mixture such as this was successfully used in a pulverizer firing a 12,000-sq.ft. boiler. Lignite alone operated without trouble, but the greater weight that had to pass through the mill made crushing costs too high. The mixture was substituted, with good results. If a preheater is provided to drive off excess moisture, it will be found possible to pulverize low-grade lignite. When a mixture is used, no preheating is necessary.

When given a fair chance, lignite has been found an efficient power-plant fuel. The average engineer or boiler-room attendant is quite likely to condemn it, but that is due to the increased handling required. If mechanical means are employed, one man can unload coal and take ashes from a 40,000-sq.ft. plant.

PRACTICAL AIDS TO OPERATION



Engine Indicator Records Boiler Blowdown

WE NEEDED a device to record the number of blowdowns the night firemen were giving the boilers, because daily analyses of boiler water showed wide variations. An appropriation could not be obtained to purchase a recording meter, therefore I built one from an old steam-engine indicator, a worm and gear and the escapement from an old clock. The escapement wheel is mounted on one end of the worm shaft and the gear wheel on the indicator cylinder stud, as in the diagram.

Power for driving the indicator is provided by the spring in the card cylinder. The cylinder is given one turn against the tension of the spring. Then each time the escapement is released the cylinder turns about $\frac{1}{4}$ in. toward normal position. The escapement is attached to the pencil arm and is released as the arm moves in the up direction. The pressure cylinder of the indicator connects into the common blowdown line to six boilers. With a low-pressure spring in this cylinder I get a good record on the card each time a boiler is blown down. Even though the indicator does not show which boilers have been blown down, feedwater analyses are more consistent since we installed the recorder.

Wilkes-Barre, Pa. THOMAS M. STREET

Improved Heating System Temperature Control

WE HAVE heating coils in ventilating units which are thermostatically controlled. The ventilating unit for our swimming pool in the basement is on the fifth floor. This unit also serves the ballroom on the first floor. To improve ventilation a damper was installed in the air duct at the ballroom entrance. We now can control ballroom and swimming-pool ventilation individually.

The heating coil was so far from the swimming pool room that not enough heat was available in zero weather, so we installed a 300-lb. radiator in the air duct leading to the pool. The air-duct structure was not heavy enough to support this radiator, so two hangers were made of $1\frac{1}{2}$-in. pipe and anchored to the floor and across the duct into the brick walls on either side.

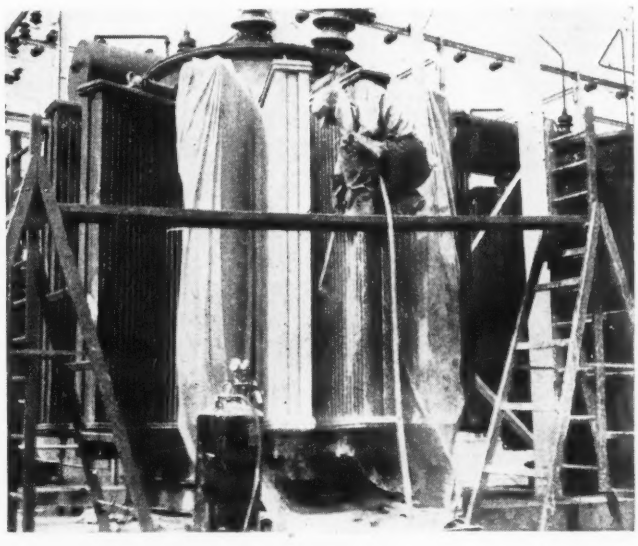
These hangers were placed so they supported the radiator at each end. It was laid flat, given proper pitch and was piped into the steam and return lines of house heating system. For better control we extended the radiator-valve stem outside the duct and put in a hinged entrance panel. We have had no more complaints on temperature.

Chicago, Ill. ABE ROCKLIN

Removing Paint From Transformer Radiators

OIL-INSULATED self-cooled transformer tanks and radiators require a finish that protects them against rust and gives maximum heat radiation. This makes it advisable to clean the old paint off transformer radiators before repainting, because of the heat-insulating effects of a thick coat of paint. Also, when the base metal has not been seen for several years, it is often surprising the amount of rust and corrosion that has developed. Most engineers agree that the new coat of paint should be applied to base metal, but it has been difficult to remove the old paint.

Sandblasting is a common way of removing paint, but on transformers it is difficult to direct the blast on the inner surface of the radiator tubes. The cost of doing the work is high and the dust is objectionable. Other methods include applying solvent paint removers or hot alkaline solutions and removing the radiators and immersing them in a tank of hot alkaline solution. Another method developed to be applied in the field is to mix a quantity of Oakite cold strip in water to make a solution of a consistency that will flow evenly over and adhere to vertical surfaces of the transformer, without excessive drainage. The solution is placed in a pressure tank, and sprayed over the surfaces to be cleaned, as shown. We find



that usually 15 to 25 lb. air pressure gives the most desirable flow. The portable air compressor, a part of usual paint-spraying equipment, is generally of sufficient capacity to maintain desired pressure in the spraying tank. A special-shaped nozzle allows the solution to be applied to the rear surface of the radiators and tubes, either by back splash or direct hit. The solution is allowed to remain on the coated parts for from 20 to 30 min. after which it is rinsed off with a nozzle similar to that used for spraying on the solution. To speed up rinsing, water pressure should be as high as possible. After rinsing, the solution is applied again until the paint is completely removed. Usually three or four applications are sufficient. The number of alternate applications and rinses depends upon the character of and number of coats of paint being removed and the effects produced by weathering.

New York, N. Y. DAVID HEARN
Oakite Products, Inc.

Automatic Coal-Feed Regulator

LACKING an automatic coal-feed regulator on our boilers, which operate at 170 to 175 lb. pressure, I decided to design and build one. The results of these efforts are shown in the diagram. A small pressure gage was fitted with a special gear so that its pointer moves about $\frac{1}{8}$ in. per lb. change in boiler pressure. The pointer spindle and hub were threaded so that the former can turn in the latter. If the pressure drops below 170 lb., the pointer rests on a stop and the spindle screws out through its hub. When the pressure rises above 170 lb., the spindle has screwed back to its limit in the hub; and the pointer moves around the scale as the pressure increases.

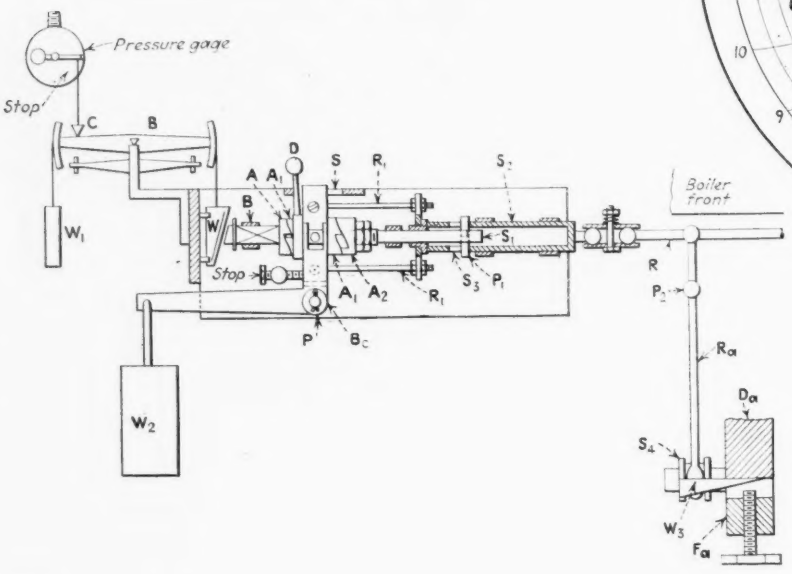
Mounted below the pressure gage, a beam B, supported on knife edges, carries wedge W at one end and weight W_1 at the other. A conical weight attached to the gage pointer rests in a conical cup C on beam B. The conical weight plus weight W_1 overbalances wedge W, causing the left-hand end of the beam to fall and lift the wedge, when the pressure drops. As pressure increases, the gage pointer lifts the conical weight off the beam and wedge W falls to decrease the combustion rate. When steam pressure reaches blowoff value, the right-hand end of beam B rests on the limit stop and the cone weight is lifted clear of cup C.

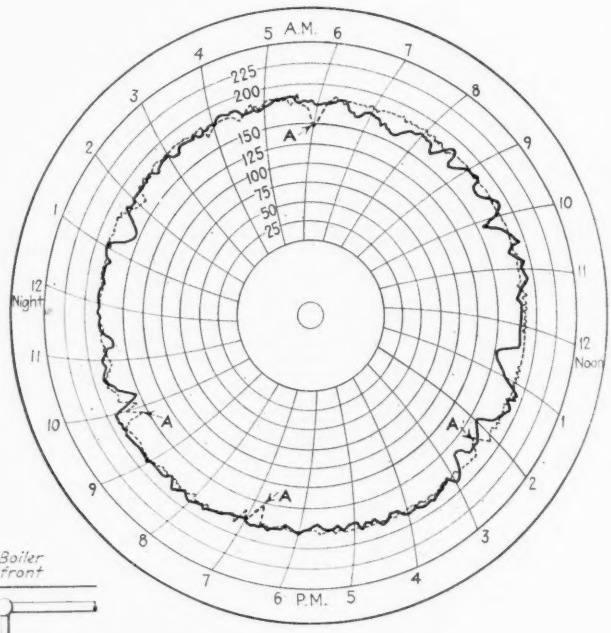
Cam A_1 is supported in a bearing and is rotated through about a 110-deg. arc by driving arm D connected to the stoker feed plate and therefore moving at the same speed. Cam A cannot rotate, but is supported in bearing B and moves endwise as cam A_1 rotates back and forth. Cam A_1 is carried in a bearing supported in the bell crank B_c, pivoted at P. The top end of cam A_1 bearing support is guided in slot S. When the top end of the bell crank is forced to the right, weight W_2 is lifted.

Cam A_2 is supported on shaft S_1, the left-hand end of which connects to a sleeve S_2 by pins P_1 and is free to move in slots S_3. Sleeve S_2 connects to cam A_1 bearing support by two rods R_1. At its right-hand end sleeve S_2 connects by a flexible coupling to rod R that runs across the boiler tracks. Rocker arm R_a, pivoted at P_2, connects to rod R at its upper end and to sleeve S_4 at its lower end.

Sleeve S_4 carries a wedge W_3 that extends into the lost motion space between the driving arm D_a, with its constant arc of travel, and feed-plate arm F_a. As wedge W_3 is moved into or out of the space between the stoker driving and feeder arms the lost motion between the two is decreased or increased and the rate of coal feed increased or decreased accordingly.

In the figure, wedge W is shown in middle position, which is for normal pressure. When driving arm D is pulled down by the movement of the stoker mechanism, cam A is moved to the left until it contacts wedge W. The wedge stops endwise movement of cam A and cam A_1 is forced to the right, against the pull of the bell crank B_c, a distance equal to that which cam A was prevented from moving to the right. This movement is transmitted to sleeve S_2 and rocker arm R_a, positioning wedge W to control the fuel feed.





Above—Steam pressure chart before and after the coal-feed regulator was installed

Left—Automatic coal-feed regulator connected to chain-grate stoker

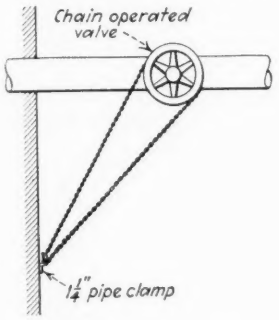
As steam pressure is increased, cone weight C is lifted off beam B and wedge W falls to a lower position, increasing the distance that rod R is moved to the right. This action moves wedge W_3 to the left, thereby increasing the lost motion in the stoker drive, thus slowing down the coal-feed rate. A decrease in steam pressure produces a reverse effect to increase the coal-feed rate. Special dampers were constructed for the forced draft-fan wind boxes and the regulator controls combustion air flow along with stoker speed.

Steam-flow air-flow meters and CO_2 recorder are installed so that operation can be closely checked. Improvement in steam pressure since the regulator was installed is shown on the chart. The full line is steam pressure before the regulator went into service, Jan. 29, 1932, and the dotted line steam pressure Jan. 5, 1935. The former was obtained by a good fireman giving careful attention to his job, while the latter was obtained with the regulator in service and a minimum of attention by the fireman. Pressure drops, marked A, occur when the fires are being cleaned.

Edmonton, Alt. F. T. POLLOCK
Government Power House

Hanger for Valve Chains

THE chains of chain-operated valves, if allowed to dangle in passageways, are a nuisance and a hazard to operators. Inconvenience, possibly accidents, can be avoided if all such chains are hung up out of the way. Convenient valve-chain hangers can be made from ordinary one-hole pipe clamps or "jiffy straps." For the usual sizes of chain, a $1\frac{1}{4}$-in. (pipe-size) clamp should be used. This size clamp can be readily adapted by sawing off approximately $\frac{1}{2}$ in. of metal from its tip and rounding the rough edges with a file. By fastening the hanger on a convenient wall or column at a height within reach of a man and at a sufficient distance from the valve to avoid a loop in the chain, it can be kept out of the way of those who may pass under the valve.



Waynesboro, Va. S. H. COLEMAN

It's Easy to Build A Pit Engine Muffler

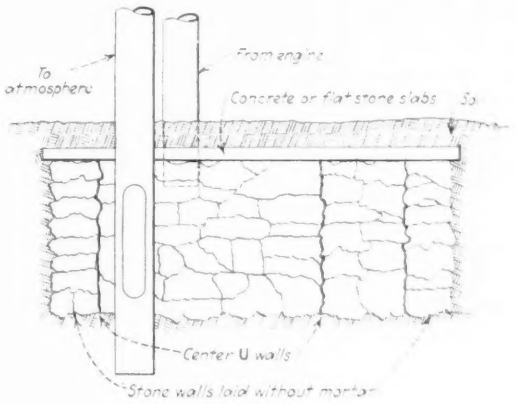
USERS of small stationary internal-combustion engines can construct an efficient muffler at little cost by running the exhaust pipe into a pit dug outside the engine house. Dimensions for the pit depend upon size and number of cylinders and engine speed. With slow-speed single-cylinder engines, the ratio of piston displacement to pit volume may be around 1:150. Heat dissipation becomes the controlling factor at higher speeds with multi-cylinder engines.

The pit should be rectangular, walled with stone laid without mortar. A dividing wall of the same construction, making a U-shaped chamber, will add to the efficiency by providing additional sound absorption. Provide a drain if needed. Cover the chamber with flat stones, concrete slabs, or metal plates and refill with earth. This construction if properly done will last for many years.

The inlet pipe should be at one end of the U and the outlet at the other, as in the figure. For the latter drive a pipe vertically into the pit bottom and of length sufficient to project at least 6 ft. above ground. Before driving, cut a hole in each side of the pipe at a point which will be about equidistant from top and bottom of chamber as indicated.

It is surprising how efficient mufflers built in this way can be. Back pressure is low. A few feet away, vapor rings alone indicate that the engine is in operation. I have muffled 2-cyl., 140-hp. engines in this way with entire satisfaction.

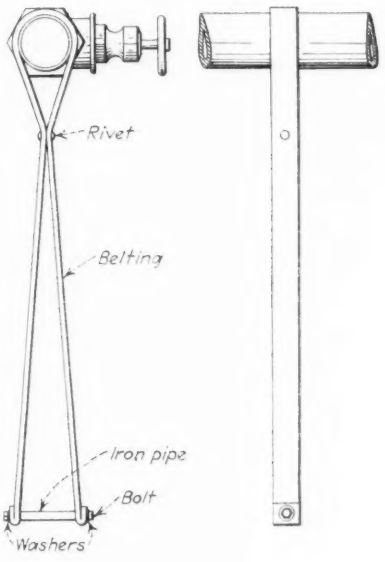
Lockport, N. Y. J. G. LATTA



Piece of Belting Makes Step to Reach Valve

A 6-IN. valve was placed about 2 ft. higher than a man could reach. The space beneath had to be kept clear. A ladder would have to be moved out of the way. A box used to reach the valve was always being taken away by someone and usually had to be searched for every time the valve was opened or closed.

To solve the problem, a length of discarded 2-in. belting was thrown over the pipe and riveted together just beneath it, as in the figure. The ends of the belt reached to within 2 ft. of the floor. Both ends were doubled, holes punched for a bolt, and a piece of iron pipe placed between them. A bolt was passed through the assembly and nuts with washers tightened on the bolt. By gripping the riveted part with one hand, a man can put his foot on the pipe step and easily reach the valve wheel. When he has finished, the belt can be moved along the pipe out of the way near the wall.



H. MOORE
Hamilton, Ont.

CURRENT COMMENT

"Fallacy No. 6"

IN CONNECTION with "Fallacy No. 6" outlined in your January number, some of us may remember that at different times claims have been made that when a low-pressure heating load uses all the exhaust steam from an engine, the demand for steam to take care of the combined power and heating load is less than that for the heating load alone, when the radiation is supplied directly from the boiler through a reducing valve.

This would appear to be a quite obvious fallacy, but reference to the published correspondence would indicate that the claim has sometimes come from reliable sources, backed by apparently accurate operating records, so perhaps it might be worth while to give the matter a little further consideration.

Assume that we are producing saturated steam at 100 lb. pressure; total heat will be 1,188.8 B.t.u. When this steam is put through a reducing valve, the total heat remains the same and if reduced to 5 lb. pressure it will have about 75 deg. of superheat, which everyone knows is "bad medicine" for radiators.

The practical results will probably be that some of the radiators, especially those nearer to the boiler, will fail to heat in a satisfactory manner, and an effort will be made to speed up the circulation and discharge steam from the radiator at a high temperature instead of getting complete condensation, whereas at the far end of the system the radiators may be operating efficiently with more nearly saturated steam.

Uneven conditions often lead to the overheating of some parts of the building and waste of heat through opening the windows instead of turning off radiators.

In discussions of this nature, the fact that steam becomes superheated when passing through a reducing valve is often overlooked, and may account for the discrepancies which sometimes appear between estimated and practical results.

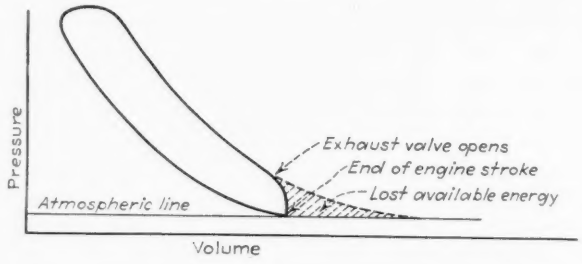
Bloomfield, N. J. JAMES O. G. GIBBONS
Consulting Engineer

Not Diesel Power for Nothing But Better Efficiency

IN THE April number of Power, page 211, Prof. B. E. Fernow commented upon the use of exhaust-gas turbo-blowers for super-charging diesel engines. He indicated that, in his opinion, the law of conservation of energy was being violated in connection with a previous statement by Paul R. Sidler to the effect that the energy so utilized would otherwise be lost.

I should like to refer Professor Fernow to the fundamental thermodynamics of internal-combustion engine cycles. No internal-combustion engine utilizing a simple piston, crank, and connecting-rod mechanism is able to expand the products of combustion down to atmospheric pressure. This applies to both Otto-cycle and Diesel-cycle engines. The exhaust valve must open before the piston reaches the end of its power stroke, to permit escape of the gases and prevent the engine from working against itself. Pressure in the cylinder at the instant the exhaust valve begins to open may be 75 lb. per sq.in. or more under full-load conditions.

It is, therefore, obvious that there is a considerable amount of available energy lost in the exhaust of an internal-combustion engine which could be utilized by the engine if it were able to expand the gas to a greater volume before releasing



it. This can be accomplished by using a mechanism which will provide a power stroke of greater length than that of the compression stroke.

Several engines of this type have been built in years past, one of the most successful being the Atkinson engine. It was found difficult, however, to adapt the mechanism of such an engine to high-speed operation, and, furthermore, the increase in efficiency was not considered sufficient to justify the added complications.

The accompanying P-V diagram shows the available energy in the exhaust which is lost in the usual diesel engine.

The gas-driven turbo-blower provides an excellent means of utilizing a considerable portion of this energy for supercharging the engine. The law of conservation of energy is not violated any more than it would be if the discharge outlet of a steam-boiler safety valve were connected to a steam engine or turbine and the released steam made to do useful work.

Professor Fernow also commented briefly upon what he termed a "ramming effect" in connection with the intake system of an internal-combustion engine and expressed the opinion that this also seemed like getting something for nothing. If I understand Professor Fernow correctly, he is referring to the utilization of the kinetic energy of the fast-moving column of incoming gas in order to permit the maximum amount of gas to enter the cylinder. The important point in this connection is that of valve timing. Closing of the intake valve must be delayed long enough to permit the kinetic energy of the incoming gas to fully expend itself in delivering additional gas into the cylinder, but not so long as to cause a reversal of flow due to the upward motion of the piston.

It seems to me that this is not at all a case of getting something for nothing, but rather utilization of fundamental principles by means of correct design, to obtain the maximum desired effect.

Washington, D. C. PHILIP A. WILLIS
Mechanical Engineer

Another Opinion

IN THE April number of *Power* Professor Fernow seems to be of the opinion that raising the back-pressure would appreciably reduce the output of an engine supercharged with an exhaust-gas turbine blower. In the Buechi system of

supercharging, back-pressure on the engine is practically the same as that developed by the blower. Scavenging is accomplished by pressure surges in the exhaust line. The kinetic energy of the gases rushing out through the exhaust line at release is utilized in setting up an ejector action. The length and diameter of the exhaust line, the nozzle area in the exhaust turbine, and the valve timing are designed for each installation, thus making this action quite positive and dependable. Perhaps it would be well to call this the Buechi system of dense-air operation, rather than supercharging, as an engine so operated is just working in a denser atmosphere.

November, 1932, *Power* states, "Exhaust-gas turbines recover part of the energy in the exhaust gases which is wasted in a non-supercharged engine. An increase in engine capacity of about 50% is obtained with no sacrifice in thermal efficiency."

A 4-cyl., 14½ x 20½-in. diesel rated at 450 b.hp., 275 r.p.m., operating in an atmosphere of 13.7 lb. per sq.in., produced its best fuel economy at 230 b.hp. (0.385 lb. per b.hp.-hr.). The point of minimum fuel consumption with Buechi supercharging was 0.367 lb. per b.hp.-hr. at 345 b.hp. In this case not only the capacity of the engine was increased but the fuel economy was improved as well. This is due to increased mechanical efficiency, and partial utilization of the energy of the exhaust gases, which more than offset the energy required by the exhaust-gas turbine to operate the blower.

Walthill, Neb. JAMES K. LUDWICKSON

Eliminates Dust to Prevent Brushes Sticking in Holders

I SHOULD like to supplement W. E. Warner's brief article "Why Brushes Stick in Holders." in the April, 1935 *Power*. In our plants, most machines are cleaned each night, when out of service, and the rest are cleaned once a week. For doing the cleaning, a compressed-air system is provided with outlets at suitable locations for attaching a hose equipped with a fibre nozzle. Vacuum cleaners of various styles and designs were experimented with to eliminate blowing dust from one location to another, but they were to be found unsatisfactory.

Dirt blown out of the machines was found to be copper from the commutators and rings, and carbon and graphite from the brushes. Tests made at the louvers where air comes into the plant indicated that very little dirt entered at the intake. To eliminate dirt insofar as possible, experiments were made with brushes to obtain grades having abrasiveness to give good commutation at normal loads, stand up under abnormal operating conditions and give a minimum of copper and carbon dust. These tests have resulted in materially reducing dusting.

I do not agree with Mr. Warner's recommendations to dust the brushes and holders with graphite powder after cleaning to prevent the brushes sticking in the holders. We are trying to eliminate dusting of all kinds and have not had a brush stick in its holder for years. The nearest we ever came to sticking brushes was once when it was observed that certain brushes on one machine would get cherry red. A spot at one end of the toe of certain brushes would become incandescent and proceed across the toe and finally the entire brush would glow for a second. It was noticed that the commutator was tracked with smudge, which caused selective action of the brushes. Hand stoning the commutator eliminated the trouble. Even though the brushes were heated to incandescence they did not stick in their holders, indicating that proper brush and holder tolerances had been used. I believe that if the brushes and holders are correctly designed, proper grades of brushes used, commutator and rings maintained in good condition and correct brush tension used, brush sticking problems will be eliminated.

North Bergen, N. J. KERMIT B. HOFFMAN.

What About the Bonus System

I HAVE had considerable experience with the fireroom bonus idea, extending over the past eight years. A short summary of our operations appeared in the April, 1930, number of *Power*.

Since that time several changes have been made in our methods, each time endeavoring to reduce costs. I think the bonus system is one that I would not care to abandon, as it has produced results far better than anticipated. Prior to its adoption our overall efficiency was 68.5%, at this time the bonus incentive was based at 69%. This base has since been changed to 71.5%.

To the casual observer, this would seem unfair to the workmen, but the reason for this change is just, as the owners have invested heavily in improvements, all tending to increase the efficiency of the plant. High-grade fuel is purchased, particularly suited to the firing equipment, feedwater treatment has been applied that actually does its work, and no mechanical boiler cleaning has been done for 2½ yr. Strictly high-grade refractories are used. All this allows the boilers to be kept in continuous operation, and the resulting losses of burning down fires and rekindling after outage is avoided. This also tends to reduce costs in refractory maintenance, as the constant cooling and reheating of the furnace linings is one of the most expensive operations an owner has to contend with.

Average boiler efficiency for the past five years is 73.6%. This efficiency tends to improve each year. During 1934 it was 75.1%, and for that year the participants were paid $2,200 as a bonus.

When first established, the bonus plan idea was to pay each participant one cent per hour for each 0.2% increase over the established base. This has since been changed to a far more complicated system, but the figure arrived at is approximately the same. There is no good reason to be advanced for this change, as it only makes the plan look that much more complicated.

As it now stands, the owners get approximately ⅔ and the operators ⅓ of the coal savings over the base figure. While it would seem that the owners get the major portion of the savings, it must be remembered that a large portion of their share is spent in improvements, all of which tend to increase efficiency.

The system has developed our employees, and certainly has made the boiler room a much easier job to handle, as we get cooperation from the men. Of course, once in a while an employee develops the idea of trying to "beat" the job, but fortunately the real workers watch the job too closely for such a one to succeed.

New York, N. Y. W.R.P.

READERS' PROBLEMS

QUESTIONS for Our Readers

DOES A TRAP CONSUME STEAM?

Question 1

OUR *plant has two separating traps which receive steam and condensate at 125 lb. pressure. Each trap discharges to an open heater operating at 5 lb. back-pressure. The heater is below the traps. It is proposed to run the condensate discharged from the traps to a closed boiler-feed system using a return trap. The separating traps will then have to discharge to a receiver 30 ft. above them. The receiver of the return trap is to be kept at a pressure of 50 lb. during the filling period. Will it take more steam to push the water up 30 ft. to the closed boiler-feed system than it does to the heater below the trap?*—R.E.P.

DEGREE-DAY AND WIND VELOCITY

Question 2

FOR *some years it has been customary to estimate building heating requirements on a degree-day basis. I have been told recently that wind velocity is also an important factor and one not considered in normal estimating. How much effect does wind velocity have? Is it worth considering? Where can I get data on its effects and how to design for them, if it is necessary?*—E.N.R.

Suitable answers to these questions from readers will be paid for if space is available for their publication.

Reducing Oxygen

LAST *Spring our 15,000-sq.ft. H.R.T. boiler was completely destroyed by corrosion. On this boiler the feedwater was fed through the blowoff line (in the rear). Feedwater is all condensate except what is lost or blown off through the blowoff. The makeup water is from the city main and has the following analysis:*

pH value	7.1
SiO_2 grains per gal.	0.2
Ca grain per gal.	2.3
Mg grains per gal.	0.4
HCO_3 grains per gal.	1.4
SO_4 grains per gal.	20.6
Cl grains per gal.	0.9
O_2 cc. per liter	7.2

A new boiler of the same size and make was installed under the same old conditions and operating supervision was turned over to me. First I raised the boiler 20 in., making it 50 in. from the grate (Iron Fireman). The feed line was moved to the front just above the tubes. Our first sample of condensate feedwater contained 9.54 cc. of oxygen per liter. Sample from water column contained 1.05 cc. per liter. Our 7x7-in. single-plunger vacuum pump was overhauled, but could not raise 1 in. of vacuum. In fact, it had not for the past six years. All return lines are underground. All thermostats were leaking badly. After fixing all thermostats on radiators, unit-heaters, and still no vacuum, I put in a water meter on the make-up water line. It showed that we used 1,500 to 2,000 gal. of make-up water with one blowdown in 24 hr., the blowdown being only 100 to 125 gal.

One warm day I shut off all radiators and put a water pressure of 50 lb. on the return lines. I found many bad leaks. Now our vacuum is 4 to 10 in.; automatically cuts in at 4 and out at 10. The pump handles all the condensate and the vacuum. Running time is from 3 to 4 min. and the pump stands idle 10 to 15, sometimes 20 min. holding a good vacuum.

Now our feedwater still contains 3.54 cc. of oxygen per liter. The pH is 7. Our boiler-water sample taken from the water column shows oxygen 0.11 to 0.07 and pH 11.2. I treat our city or make-up water with 15 oz. of 58% soda ash plus 1 oz. of caustic soda, to every 1,000 gal. of city water added, as we only use now from 100 to 150 gal. of make-up per 24 hr. (which equals our blowdown).

What can I do to reduce the oxygen without expensive equipment? On top of the pump I made a big air chamber with automatic float and air-relief valve. It works well. Near the boiler in the pump-discharge line I put in a tank (20 in. in dia. x 4 ft. long) with float and air-relief valve, but still a lot of air is drawn in at the radiator air valve as the thermostat cuts the steam in and out as the room temperature changes. Is it all right to use sodium sulphite? How much? How often should I blow the boiler down? How little oxygen or how much is harmful? Where can I get a good easily understood book on boiler feedwater and feedwater treatment? J. K.

(The following reply was prepared for POWER by William J. Ryan of the Water Service Laboratories, Inc., New York, N. Y.)

The proper thing to do first is to repair all leaks to minimize the amount of air entering the system. An open heater is the best way to remove such air as does leak in. If the installation of an open heater is out of the question, sodium sulphite can be fed to the boilers. It reacts with the oxygen to form sodium sulphate. One company now markets a preparation of sodium sulphite for this purpose. The amount required is about 16 lb. of sulphite per million pounds of boiler feed, for each cc. of oxygen per liter. In this case with 3.54 cc. of oxygen per liter in the feedwater, the amount of sulphite required will be high. For boilers without economizers, the procedure is to keep an excess of sulphite in the boiler to react with incoming oxygen. Samples of the boiler water must be tested periodically to see that an excess of about 30 parts per million of sodium sulphite is maintained. Directions for making the test can be obtained from suppliers of the material.

The amount of soda ash being fed is about correct for a water having the stated analysis. It might be well to discontinue the caustic soda, and increase the soda ash a little, say about 2 oz. per 1,000 gal. of make-up. Caustic soda is formed in the boilers by any excess soda-ash which breaks down as a result of the boiling. Enough soda-ash should be fed to maintain a certain alkalinity in the boiler water; this helps to prevent corrosion. The water should be tested at frequent intervals and the total alkalinity maintained at about 150 to 250 parts per million (8.8 to 14.6 gr. per gallon). The test is simple and can be made in two or three minutes. The necessary apparatus and reagents can be obtained from any laboratory supply house.

Maintaining proper alkalinity in the boiler may arrest the corrosion without the addition of the sulphite. It would be worth while to try it for a time and observe the results. It would also prevent the deposit of hard scale.

The make-up water contains about 40 grains of dissolved solids per gallon. To limit the concentration of dissolved and suspended matter in the boiler to, say, 300 gr. per gal. the blowdown should be 13% of the make-up. Liberal blowdown should be used when soda-ash treatment is started, as old scale deposits may be loosened thereby. Also a careful watch should be kept for any foaming, particularly if the boiler is now dirty.

A good book on boiler feedwater treatment is "Boiler Feed Water Purification" by S. T. Powell, published by McGraw-Hill Book Co.

ALIGNING BEARINGS ON A MOTOR-GENERATOR

ANSWERS to April Question 1

The Question

WE HAVE *a 500-kw., 4-bearing motor-generator set. I have reason to believe the bearings are out of alignment. Can alignment of these bearings be checked without taking out the rotor? If so, how? If the rotor must be taken out, what is then the best way to check bearing alignment?*—M. R. B.

Gives Five Causes of Misalignment

THE machines may be out of line because: motor improperly aligned with generator, poor foundation, worn bearings, coupling out of true, bedplate warped or twisted. Flexible couplings should be as carefully lined up as solid ones. Their alignment can be checked and corrected by removing the coupling bolts

to free the machines, so that one can turn without the other. Lay a straight-edge across the coupling peripheries parallel with the shaft in four positions, top, bottom and both sides. Turn the rotor 180 deg. and again check at the four positions. Then turn the armature 180 deg. and repeat.

If in any of these positions the straight-edge is found to be slightly lifted away from snug contact with one coupling half, check the diametrically opposite point to see if the reverse effect appears. If so, the shafts are out of alignment.

To make sure one machine is not skewed or tilted with respect to the other, insert a feeler between the coupling faces at the four points mentioned. If the gap is not uniform, misalignment should be rectified by skewing over or shimming up the offending machine. When the gap is shorter at the top than at the bottom it may be due to worn bearings. This can be checked by jacking up each shaft separately and noting the lift. Place a spirit level on each shaft and if either is not level correct this by shimming the machine.

When the coupling halves are out of true or of different sizes, before a check on misalignment can be made satisfactorily the coupling must be renewed, placed on a true arbor, faced in a lathe, and its diameters turned to the same size. After the coupling is replaced the machines should be adjusted until the straight-edge is in snug contact across the entire surfaces of both coupling peripheries, and the gap between faces is uniform, at four positions 90-deg. apart.

Toronto, Ont. L. A. HUNT

Uses Lead Strips to Take Measurements

REMOVE the shaft and string a piano wire along the centers of the bearings, held tautly by a frame at either end. Then take careful measurements with calipers along the vertical line of each bearing between the bottom of the brass and the piano wire. Do this on both sides. If measurements tally, the bearings are in line.

If you do the job with the shaft in place, follow a rather different procedure. Assume that there is no sag in the shaft. Remove the top caps and top brasses and wipe the shaft along the width of each bearing with a very thin film of red lead. Give the shaft a complete turn, making sure that the bottom halves of the brasses do not turn out. The red lead will now be on top as before, and an indication of the loadings may be had.

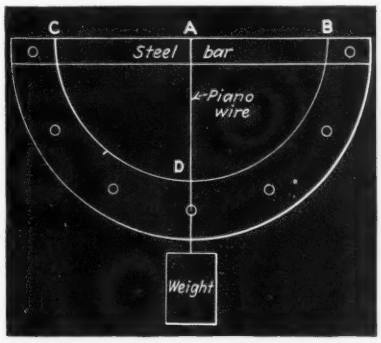
It may be advisable here to turn out one or more of the brasses and use a scraper on any hard spots. Then, try with the feelers at both ends of each brass at the lowest point. Try again part way around on both sides of each bearing. Make any adjustment that may be necessary. Then place two strips of thin lead wire around the shaft at each bearing end, replace the top brasses and caps and tighten them down hard, marking the positions of the nuts on the studs. Then remove them. Inspection and measurement of the lead strips' thickness will show whether the top brasses should be closer to the shaft. If so, a shim or two should be removed. If there are no shims file the brass.

Before final assembly make sure that the top brasses do not tend to bind the shaft at the sides when screwed down. If the leads show a tendency to do this, scrape a clearance to remedy the fault.

Passaic, N. J. MARK BELL

Check Bearings With Piano Wire

THERE is no satisfactory way to check bearing alignment in a 4-bearing machine without taking the rotors out. Remove the rotor, replace all pedestals, if any, and dowel and bolt in place. Put in the lower half of the four bearings. Bolt a steel bar on the housing flange as in the figure. Find exact center *A* by using inside micrometers from *A* to *B* and



A to *C*. Put companion steel bar on outboard bearing pedestal at other end of set. Stretch a No. 20 steel piano wire across the two steel bars, and hang all the weight on each end that the wire will support without breaking, tight enough to hum when struck.

Put Prussian blue or red lead on end of micrometer head to tell when a light touch is reached. Take measurements around the wire each time it is moved to right or left until the exact center *A* is found at each end. Rub blue chalk on wire and steel bar, where the wire crosses it, lift the wire to one side and file a slight groove in the steel bar where wire rested on it. Replace wire in grooves and recheck with micrometers at both ends.

Now check the alignment of the two inside bearings, from *A* to *B*, from *A* to *C* and from *A* to *D*. Move each one until they check with the end bearings. Alignment will then be correct. If the coupling faces are true, they should be in almost perfect alignment.

Detroit, Mich. LEONARD LONG

Checks Alignment at Coupling

TO ALIGN the machines, dismantle the coupling, and if of the pin type, insert a pin without its bushings. Make two marks, one on each half of the coupling. Be sure the shafts are pushed as far apart as thrust bearings or collars will permit. With feelers or thickness gage, measure the distance between coupling halves when the marks are on top. If half of the coupling is high, determine the amount above the other by using a straight-edge and feelers. Then turn both marks to the right one-quarter turn, and repeat the measurements, remembering to measure at the marks. Repeat the measurements at the bottom and left-hand positions.

If the distances between the two halves of the coupling at the four positions are the same, the shafts are parallel. If the straight-edge lies on both coupling halves at all four positions, the shafts are in line sideways. When both conditions are not fulfilled, the bearing pedestals must be shifted, or shimmed.

With claw-type couplings, a test rod can be clamped between the claws of one shaft. The test-rod point is placed close enough to the periphery of the other shaft to measure between with feelers. To determine if shafts are parallel, measure between adjacent marked claws with calipers.

Milwaukee, Wis. LAWRENCE M. LARSON

CENTRIFUGING DIESEL LUBRICANTS

ANSWERS to April Question 2

The Question

WE HAVE *two 400-hp. diesels in our power plant, one operating continuously, the other coming in during peak-load periods. How often ought we to centrifuge our crankcase lubricating oil? Should it be allowed to settle first? Is there any advantage in adding water before centrifuging? If so, should the water be at room temperature or warmer? We have several opinions among our operators and would like to check practice of other stations.*—J.J.K.

Use Superheated Steam

IF YOU use the batch system, drain all oil through a sateen filter into a steel drum having a drain and pipe connection at the bottom and properly vented at the top. Drive 400-500-deg. F. superheated steam through the oil by means of the bottom connection. Hold the oil at this temperature for 1 hr. Crack the drain slightly if the drum fills up. After shutting off steam, allow the oil to cool to about 180 deg. F., then centrifuge.

Fuel-oil dilution, if any, will be driven off by the steam, as the steam condenses, the distilled water produced will dissolve and keep in solution the acidulous products of oxidation, which are more stable in hot water than in oil. We also reduce the neutralization number of the hot oil at the same time by washing in water having a pH of about 7 and free of any contaminating inorganic compounds.

When no steam is available, the oil may be washed in pure boiling hot water. Practically the same results will be obtained, except for driving off fuel-oil dilution.

Oil analysis is the only way to tell how often to centrifuge. There are too many factors governing contamination to permit any specific reply.

Augusta, Ga. R. C. BAKER

Add Water

IN OUR 1,750-hp. plant, a continuous-bypass system maintains oil in very good condition. An occasional supplementary batch treatment of the oil may be desirable to remove any impurities that accumulate in crankcase corners

and are not ordinarily drawn into circulation.

There is little advantage in settling the oil first. We find, however, that addition of water before centrifuging makes a decided improvement. Water is added to the oil ahead of the heater, and the oil and water heated together to 150-180 deg. F. The amount of water added is adjusted so that the water discharge carries a small amount of oil. This lessens the possibility of the clean-oil discharge carrying any water. The water dam in the bowl should be selected of a size to handle a large enough stream to keep the water-discharge passage in the bowl from clogging by "globs" of carbon and sludge discharged with the water. A little experience will soon indicate the proper amount of water to use, and an occasional inspection will show any irregularity.

This system at our plant maintains oil nearly up to the color of new oil. After oil is once put in good condition, it will probably not be necessary to run the centrifuge all the time the engine is running.

Longmont, Colo. V. F. SHUMAKER

Centrifuge Continuously

THE purpose of centrifuging lubricating oil is to insure cleanliness of the system by removing moisture and solid impurities which have a tendency to settle out and interfere with efficient operation of the diesel. Obviously, highest efficiency of the lubricating system can only be maintained if the oil is kept clean all the time, therefore, the oil should be continuously centrifuged. The rate of centrifuging should be so gaged that the entire amount of oil in the system will be passed through the centrifuge the equivalent of three times per day. If the present set-up of the engines does not permit continuous purification, and it is impossible to change the system, the oil should be drained at least once a week and centrifuged thoroughly. No particular advantage is to be gained by allowing the oil to settle first if treated in the batch system, and ordinarily no water need be added.

Philadelphia, Pa. H. P. WILKINSON
The Sharples Specialty Company

No Advantage in Settling

THERE is no advantage in settling the lubricating oil prior to centrifuging. The centrifugal action of the centrifuge is from 6 to 15,000 times more powerful than the force of gravity, depending on the type of machine used. There is not much advantage in adding water prior to centrifuging, although there is the possibility of the added water when removed by the centrifuge slightly reducing the organic acidity or neutralization number of the oil. The oil will centrifuge better and more quickly if it is heated to about 130 deg. F.

The continuous by-pass method of lubricating oil purification is best. A certain proportion of the oil, possibly 5% of the stream from the lubricating-oil pump discharge, is passed through the centrifuge continuously while the engine is in operation. Even though the oil is handled by this method, it is advisable to give it a batch treatment every so often, depending on the quality and condition of the oil. Naturally a high-grade oil will stand up better in service.

Colloidal or soluble sludges are held in suspension above 100 deg. F. Some soluble sludges will precipitate at low temperatures. If chilling apparatus is available, the oil could be treated by that method prior to centrifuging for the insolubles.

It is assumed the 400-hp. diesels have trunk pistons. If so, considerable carbon will work down into the crankcase oil. Neither the centrifuge nor static or cloth-and-tray filter will remove carbon in colloidal suspension. If it is desired to remove this the oil should be treated by the batch system. It should be placed in a tank; about 1½ lb. of "Gold Dust" or similar washing powder should be added to each 120 gal. of oil. The mixture is thoroughly agitated with low-pressure steam blown into the tank. After settling for several hours, being kept warm during this time, the top layer of clean oil can be drawn off. The water and sludge in the bottom can then be dumped.

Ordinary settling in a tank is the simplest of all purifying methods. There must be no agitation with this method and the oil must remain perfectly still. In some cases sediment will settle out overnight, and in other cases a week or more might be necessary. Some impurities are so light it is necessary to heat the oil to about 180 deg. F. by blowing steam into it. This method not only heats the oil, but acts on the impurities in such a way as to cause the very light suspensions to be thrown down to the bottom of the settling tank, together with the heavier precipitates. After sufficient agitation and a quiet settling afterwards, the clean oil can be drawn off.

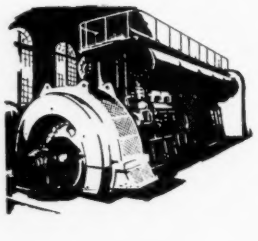
New York, N. Y. "P. TROLEUM"

Continuous System Works

TO GET best results, centrifuge lubricating oil continuously. Dirt particles, dust, water from leaky pipe joints will get into the oil in spite of all precautions, therefore, to keep bearing wear at a minimum, use the continuous by-pass system. In this system dirty oil is run through the centrifuge before going back into the engine.

In order to keep down the labor of cleaning the centrifuge be sure that you have no blow-by in your engines. If you have, rest assured that carbon particles and products of combustion are being carried into the oil, adding to the wear on the bearings, to say nothing of the extra work thrown on the centrifuge to extract it from the oil. Be sure no water is getting into the crank-case as this will foul up the centrifuge, making it necessary to dismantle and clean sooner than otherwise.

I do not advise adding water before centrifuging, unless you use batch-cleaning. If so, you will need settling tanks to settle out the water before centrifuging. Addition of water will do no good unless the mixture is agitated, which will entail extra equipment. I do advise, however, that oil be heated before centrifuging. This aids materially in extracting foreign matter, and the results more than justify the small expense of installing a heater.



We use the continuous system in our plant and the results are very gratifying, although maintenance charges on the centrifuge are a little high in spite of most intelligent handling. We are able to run our machine nearly three days before cleaning, at which time we remove about 2 lb. of solids and sludge, the accumulation of three days from one 750- and one 300-hp. air-injection diesel, the 750-hp., which is our main unit, having water-cooled pistons.

Vero Beach, Fla. HOMER D. WHITE
Plant Engineer,
Vero Beach Light & Water Dept.

Don't Remove All Carbon

THE period between oil purifications should depend upon the design and type of the engine. With an engine of 400 hp. in good condition with trunk-type pistons, once a week should be often enough to clean the oil. This can be judged by the amount of dirt removed at each cleaning. We find that centrifuging once each week is often enough. We start the centrifuge as soon as the unit is shut down, so oil is as warm as possible without heating. We do not use water when centrifuging.

When we clean our crankcases we add water to the settlings removed to float the oil out of the carbon. This mixture is run through the centrifuge, saving considerable oil that otherwise would be lost, as it would not pay to try to run the settling through the separator.

I don't believe it pays to try to remove all fine carbon from the oil. The carbon that is too light to be removed by the centrifuge is really a benefit to the used oil, as shown by the following test of a sample of oil from the case of one of our diesels. The viscosity of the used oil was found to be about 100 sec. below that of new oil at 100 deg. F. and only one point below at 140 deg. F. As 140 deg. F. is nearer operating temperature of the crankcase oil than 100 deg., the used oil is nearly as good as new oil for lubrication. The fine carbon helps hold up the viscosity as the oil heats up. One of our engines has operated 16 hr. per day for 8 yr. and this is the first year we have tightened any bearings (0.005-in. shims from two crankpin bearings). This would indicate that some carbon in the oil is at least of no harm, if not a benefit.

Each size and type of unit will govern the type of centrifuging to use, whether batch or continuous, and also the frequency. If carbon and dirt have a tendency to stay suspended in the oil, water will help settle it out. The water should be heated to raise the oil to a temperature of about 180 deg. F. and kept at this temperature for several hours for settling. The oil and water may then be drawn off and centrifuged, leaving the settlings in the tank. Some claim that soda ash or sal soda added to the mixture will cause it to settle more quickly.

Walthill, Neb. WM. W. DINGWALL
Central States Electric Co.

Automatic Control of STOKER-FIRED BOILERS

Combustion is controlled according to steam demand. Steam flow and air flow regulate stoker speed

STOKER-FIRED boilers are more responsive to changes in air supply for combustion than to changes in rate of fuel input. Therefore, the basic principle of Bailey Meter Co. meter control, as applied to stoker-fired boiler, is to control the air supply from steam pressure and to control fuel input by the steam-flow, air-flow relation.

The free-floating air pilot valve for this system is shown in Fig. 1. Air is admitted at constant pressure to the space between the two balls *B* on the valve stem Since the balls are of equal size they form a balanced valve. Being of slightly smaller diameter than the bore in the pilot-valve sleeve, a small quantity of air escapes which tends to prevent actual contact between the balls and the sleeve, and acts as a lubricant. Two outlets connect to the control cylinder so that when the pilot valve is in a neutral position, as in the figure, air pressure supplied to each side of the piston is equal and the piston remains stationary. Moving the pilot valve slightly in either direction unbalances the air pressure on the piston, and it moves.

A master-pressure controller, Fig. 2, connects to the steam header. The actuating mechanism includes a pressure element attached to the master pressure pilot valve supplied with compressed air at 35 lb. per sq.in. If demand for steam changes, a momentary and proportional change occurs in steam pressure. This causes the pressure element to reposition the master air pilot valve, to increase or decrease the air-loading pressure. The loading pressure goes through the master selector valve to the uptake-draft selector valve, one on each boiler panel.

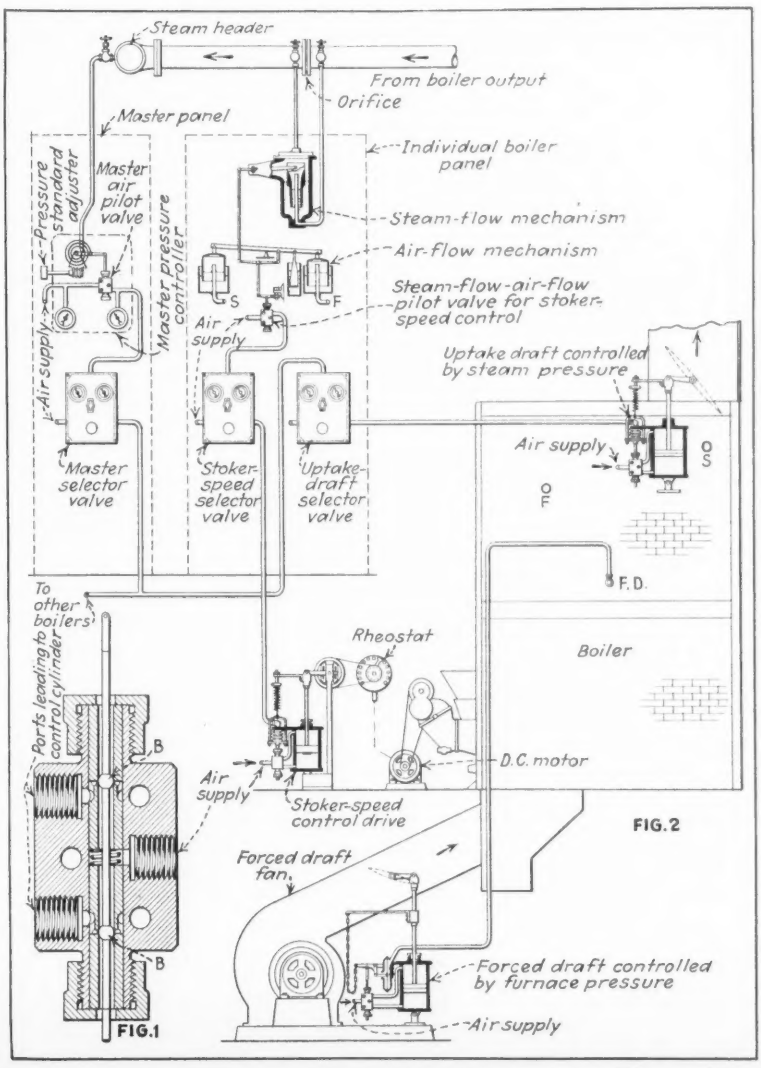
The change in loading pressure acts on a small metal bellows on the intake draft-control drive to move a relay pilot valve and admit air to the operating piston, which changes damper position proportional to the increase or decrease in control pressure. The relay pilot valve is returned to neutral by means of a spring and yoke to prevent overtravel of the control drive.

Fuel supply is controlled by a pilot valve operated from the boiler meter steam-flow, air-flow mechanism mounted on the boiler panel. Since the steam-flow, air-flow pilot valve is connected to two factors, the stoker speed is also affected by the relative positions of the steam-flow and air-flow pens. If the air-flow record rises above the steam-flow, the control will function to speed up the stroke to increase the rate of steaming. If the air-flow pen is below the steam-flow pen, the control will reduce stoker speed until the proper relation between fuel and air is restored.

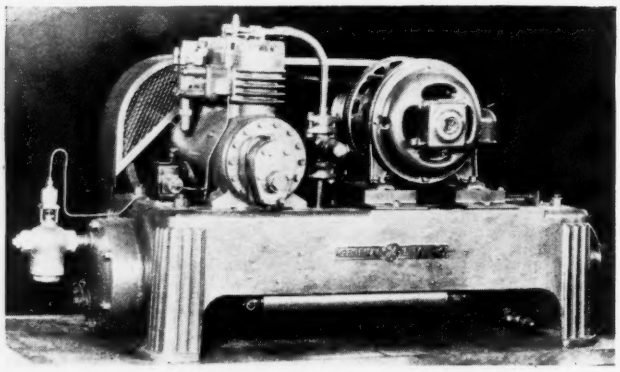
The relation between stoker speed and B.t.u. input is subject to variation in the heat content of the coal, moisture content and effects of wear on stoker equipment. However, readjustment in stoker speed is made for these day-by-day variations by the steam-flow, air-flow controller.

Furnace draft is maintained at the desired value by controlling either forced draft or induced draft, depending on the layout of equipment. In either case, forced draft is measured by a large sensitive diaphragm, as in Fig. 2, or by a suitable oil-sealed bell. In the figure, a large diaphragm actuated by furnace pressure controls the position of the forced-draft damper. Movement of the piston restores the pilot to neutral by moving a chain up and down, diminishing or adding to the counterbalance weight on the pivoted beam from which the pilot is suspended.

Fig. 1—Section through free-floating air pilot valve
Fig. 2—Layout of air-operated control applied to stoker-fired boiler



WHAT'S NEW IN PLANT EQUIPMENT



CONDENSER UNIT

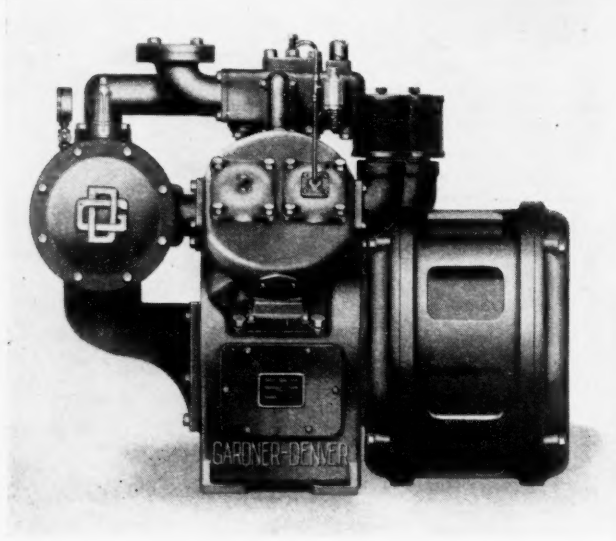
EIGHT units from 1½ to 20 hp., rated at 1.8 to 21.5 tons refrigerating capacity have been added to present G.E. line. Types CM-51S, CM-81W, and CM-81S have water-cooled, double-tube counterflow condensers, Types CM-81L, two Types CM-9L, and two Types CM-10L have shell-and-tube condenser-receivers. All types have external motors with multiple V-belt drive and compressors, liquid refrigerant filters, suction pressure controls, high-pressure safety lockouts, water regulating valves, service valves and water and refrigerant connections, also magnetic motor starting switch and thermal overload protective device for motor. Full charge of lubricating oil and holding charge of Freon refrigerant in unit as shipped. First three types mentioned are 1½, 3 and 5 hp., respectively, having refrigerating capacities of 1.8, 3.6 and 5.7 tons. Type CM-81L, 5-hp., is rated at 5.7 tons. Type CM-9L is available in two sizes, 7½ and 10 hp., with rated capacities of 8.75 and 11.5 tons. Type CM-10L, 14 and 20 hp., rated at 15.5 and 21.5 tons. "L" units are shell and tube condenser-receivers which combine condenser and liquid receivers. Seamless steel water tubes, galvanized. Tubes finned on the refrigerant side. Condenser assembly will withstand 2,000 lb. per sq.in. Heavier "L" units have one-piece, cast-iron bases. Types CM-9L and CM-10L have pressure lubrication on heavier moving parts. Valve plates improved compact design for quiet operation. All units obtainable with several different motor and motor-starter combinations, d.c. and a.c. Standard and quiet motors available; 2-speed motors for units 5 hp. and larger. Manual or automatic control.

General Electric Co., Schenectady, N. Y.

3-CYL. AIR COMPRESSORS

SIZES from 113 to 194 cu.ft. per min. displacement. This line of "WRR" 3-cyl. air compressors have two small low-pressure cylinders instead of one large, resulting in lower air temperature and corresponding saving in horsepower. Cylinder walls water-cooled. 2-stage construction gives high efficiency. Force-feed pressure lubrication by plunger pump. Pistons and cylinder walls lubricated by oil spray of crank pin. Compressor may be run in either direction. Main bearings Timken heavy-duty tapered roller type. Crankshaft compact and rigid, of chrome-nickel-molybdenum alloy ground to size and counterweighted. Connecting rod forged steel, heat treated, with steel backed, babbitt-lined ribbon-type crank pin bearings. Pistons lightweight automatic type, ground, with three compression and one oil ring on each. Valves "cushioned" noiseless automotive plate type, cushioning being accomplished by air cushion pocket in guard or bumper over each valve.

Gardner-Denver Co., Quincy, Ill.



DEEPWELL TURBINE PUMP

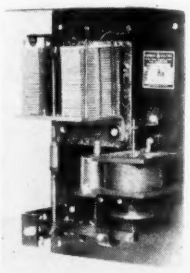
12-in. No. 2K deepwell turbine pump replaces former "A" type, with efficiencies increased to latest practice. Pump shows more than 80% all the way from 600 to 1,100 g.p.m., at a speed of 1,750 r.p.m., and performs correspondingly at other speeds. Other sizes available shortly, including 10- and 14-in. sizes.

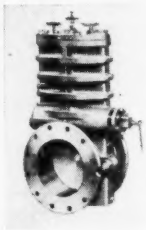
Byron Jackson Co., Berkeley, Calif.

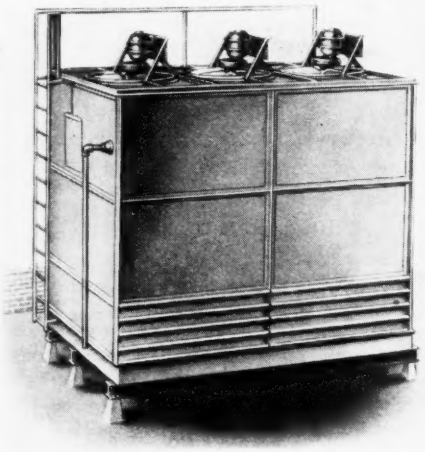
AUTOMATIC VOLTAGE ADJUSTER

TYPE G4 for use with small a.c. generators, synchronous motors, synchronous condensers and d.c. generators. Gives inexpensive regulation where voltage-regulating requirements are not too exacting. Consists of voltage-sensitive element of movable-core, solenoid type, which directly operates through levers a wide range of quick-acting rheostats. Rheostat is connected in exciter (or d.c. generator) shunt-field circuit, and any change in voltage is corrected by direct action of solenoid on this rheostat. Solenoid used for either a.c. or d.c., and in either case excited through fixed resistor from generator armature potential. Air dashpots for anti-hunting.

General Electric Co., Schenectady, N. Y.







INDUCED-DRAFT COOLING TOWERS

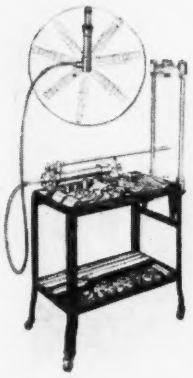
THESE towers have cooling capacities ranging from 5 to 200 g.p.m. for refrigerating plants with 1 to 50 tons refrigeration capacity, for diesel or other internal-combustion engine plants needing jacket water-cooling, etc. Water distribution through low-pressure, clogproof "Rotojet" nozzles, which spray finely atomized mist of water downward through upward currents of air induced by fan assemblies at tower top, thus assuring maximum water and air contact. Fans may be shut off during cool weather. One or more fans are used, each driven by a splash and weatherproof motor at 450 r.p.m. approximately. Standardized for ease of assembly. Bulletins.

Binks Mfg. Co., 3114 Carroll Ave., Chicago, Ill.

ORIFICE FITTING

"COMMERCIAL" orifice fitting for meter set-up avoids necessity for by-passes, thus saving space. Threaded elevator lift permits lowering or lifting of orifice plates, regardless of line pressure, without shutting down line and with entire safety to operator. Orifice plates accurately centered. Setscrews and pressure areas eliminated. Manufactured by Commercial Iron Works, Los Angeles, Calif.; distributed only by:

Foxboro Co., Foxboro, Mass.



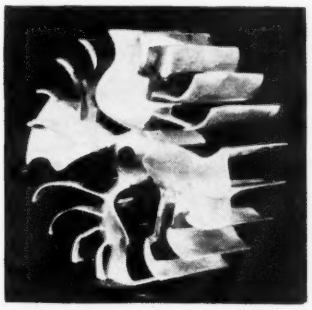
PORTABLE HYDRAULIC POWER JACK

"PORTO-POWER" jack is a remote-control hydraulic power ram. Compact and portable outfit. 7-ton hydraulic ram and a small hand-lever pump comprise unit. Connected by 6-ft. flexible high-pressure hose. Ram itself weighs only 10 lb. Also a number of auxiliary parts and accessories and a carrying tray as illustrated for use in specific applications. Jack is simply inserted wherever jacking power is required and pressure applied by hand.

Blackhawk Mfg. Co., Milwaukee, Wis.

and over motor by new type silent high-speed fan; also automatic reset and thermal overload starting switch. Service valves on side of cylinder and suction and discharge valves in compressor head. Sight oil level for lubricant. Units using either air or water for a cooling medium are available in capacities of 3,390 (at a refrigerant temperature of —10 deg. F.) to 32,650 (at a refrigerant temperature of +40 deg. F.) B.t.u. per hr. All units charged with Freon.

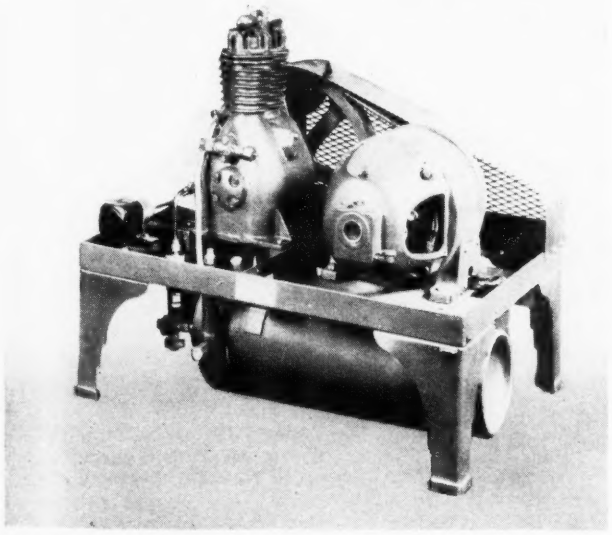
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.



BLOWER

THIS blower, cast in a single piece of aluminum alloy, is a combination propeller and multi-blade fan with vanes on tips of blades. Claimed that due to cup formation of blades at center or hub portion of wheel, uniform suction is brought about, resulting in even flow of air being deflected into blade tips with consequently high air volume and uniform discharge at low r.p.m. and low power consumption. High efficiency against static pressure.

Leinueber Air-Conditioning Co., 8448 Crandon Ave., Chicago.



CONDENSING UNITS

Low, standard and high suction pressure classifications are provided in the open commercial condensing units. Low suction pressure range units from 31 deg. below zero to 5 deg. above, Standard range 13.5 below to 20 deg. above, high from 10.5 to 40 deg. above. This range of pressures may be had in all 1-hp. and 1½-hp. models, and standard and high suction ranges are obtainable in 2- and 3-hp. models. All air-cooled units have extra-large shrouded condensers which direct entire air flow through condenser

BEARING HOUSING CLOSURES

COMPLETE closures finished and ready to use for about 150 sizes

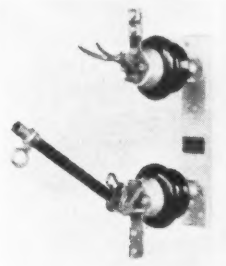
of ball and tapered roller bearings in a number of sizes and types to meet design requirements are now available. Bolt fastening dimensions have been established, and for each group of bearings having similar diameters, a number of parts all with identically located holes are provided. 14 sizes of cast-iron covers for completely closing bearing housings as well as open covers of various types. Among latter are covers carrying belts, covers with flingers and covers for accommodation of standard leather or composition oil seals. Numerous shaft extension sizes can be utilized. Varying degrees of inside space permit mounting bearings with or without locknuts in fixed or floating positions and with proper abutting shoulder diameters. A number of parts are fitted with lubricant and cleaning openings, eliminating expense of these holes in main housings. Data Sheets available.

The Bearing Appliance Co., Ardmore, Pa.

100-AMP. WELDER

A SMALL, low-priced motor-generator type arc-welding machine welds thin-gage material. Called SA-100 and delivers as low as 30 amp. at arc without auxiliary. Current range of 30 to 125 amp. Generator of single operator variable voltage type with dual control providing independent adjustment of open circuit voltage and welding current. Motor is "Linc-Weld" 5-hp. squirrel-cage induction type for across-the-line starting. Starter switch pushbutton type. Wing nut cable terminals for easy changes of polarity. Usually 220 or 440 volt, but available for 110 or 550 volt, 3 or 2 phase, 60 and 50 cycles.

Lincoln Electric Co., Coit Road & Kirby Ave., Cleveland, Ohio.



DROP-OUT FUSE DISCONNECT

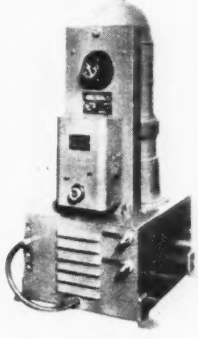
TYPE EF-2 includes standard G-E Type EG-1 fuse. When fuse blows, latch is released and switch drops to 60-deg. position. When switch is opened manually it drops to 180-deg. disconnect position. Standard NEMA voltage ratings from 7,500 to 69,000 volts. Fuse with ratings of potential transformers and up to 200-amp. size. Gas deflectors (if required) to deflect any gas within close proximity when fuse blows. 15,000-volt switch with deflectors has interrupting rating increased to 8,000 amp.

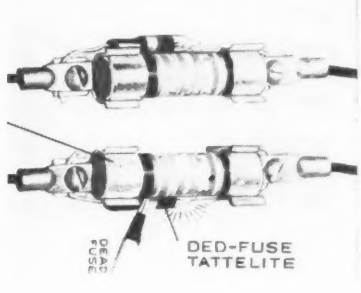
General Electric Co., Schenectady, N. Y.

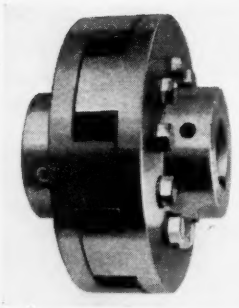
BLOWN-FUSE INDICATOR

"DED-FUSE Tattelite" is a tiny Neon lamp and casing designed to tell instantly when and where a fuse is blown. Lamp bulb itself is 1 in. long with diameter of pencil tip. Connected directly in parallel with fuse, and draws no current until fuse has blown. Adapted for use on any size cartridge fuse, and even plug fuses, since they measure only 1¾ in. long over-all by $\frac{5}{16}$ in. maximum diameter, and have 6-in. connecting leads. For circuits of 100 to 550 volts a.c. or d.c. Require 0.005 amp. current. Protective resistance built in. Also used for indicating open circuits, switches.

Littelfuse Laboratories, 1772 Wilson Ave., Chicago, Ill.







FLEXIBLE COUPLING

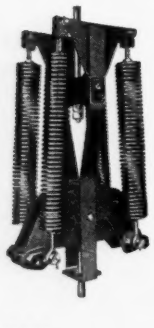
L-R Type "P" couplings have individual free-floating load cushions hung between jaws on removable studs. Sizes for shafts from 3 to 10 in. dia. Three types of cushioning material: "Metalflex," high-grade, long wearing brake-lining material used for heavy shock loads or where exposed to extreme weather; "Multiflex," a rubber-duck fabric vulcanized under pressure for use on fluctuating loads and where high resilience is required; and oak-tan leather belting for use on sustained loads and for unusual misalignment. Load cushions in plain sight for inspection at all times and can be replaced in a few minutes when necessary. Practically no wear on iron or steel jaws. No lubrication required. In operation, half of cushions are idlers, except on reversing load, thus a set of new cushions is always available in coupling itself. Cushions can be interchanged without tearing down coupling. With suitable materials and designs, capacities can be increased to 250% of rating without change in over-all dimensions.

Lovejoy Tool Works, 4976 West Lake St., Chicago, Ill.

CONSTANT-SUPPORT PIPE HANGERS

GRINNELL "Genspring" constant-support hangers float pipe-lines for movement in any direction while affording constant adequate support throughout entire range of vertical and horizontal movement. No back thrust. Three frame sizes: No. 1, light duty, No. 2, medium duty, and No. 3, heavy duty. Bulletin No. A-12.

Grinnell Co., Providence, R. I.



BRAZING FLUX

"HANDY Flux" for low-temperature brazing is entirely liquid and active at 1,200 deg. F. It dissolves oxides, including those of chromium formed during preheating, and works with steel, stainless steel, Monel metal, nickel, copper, brass, bronze and various other ferrous and nonferrous metals, permitting use of silver solders and brazing alloys with low-flow points. Flux begins to fuse at 900 deg. F., and works effectively with alloys having flow points from 1,200 to 1,600 deg. F. Does not bubble or blow away under torch. Spreads with a brush. Bulletin.

Handy & Harman, 82 Fulton Street, New York, N. Y.

IMPROVED AIR FILTER

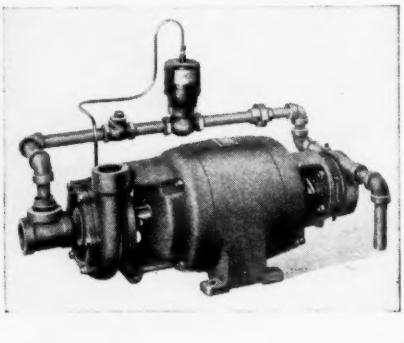
IMPROVED "Dustop" filter is fire-resistant, lower in air resistance, thus higher in efficiency, and longer-lasting. Now made of a series of coarse and fine mats of glass fibers, bonded to each other to form semi-rigid mat. Fibers laid down by machine to insure uniformity of filter pack density. Viscous material or adhesive has high dirt-holding capacity and surface tension four times that of engine oil, which means no oil vapor is entrained in air stream.

Industrial Materials Division, Owens-Illinois Glass Co., Toledo, Ohio.

AUTOMATIC SELF-PRIMING CENTRIFUGAL PUMP

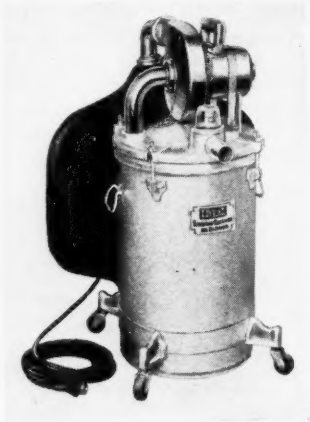
THIS Monobloc centrifugal pump has no floats, hand-operated valves or recirculation. Utilizes Worthington built Hytor, a positive primer placed on same shaft with motor and pump. Only requirement is reasonably tight suction line. When pump, utilizing latest impeller design, is primed, a pressure-operated cutout automatically unloads Hytor. Unit compact and neat with splash-proof stream-lined motor on symmetrical mounting. No tanks or float chambers. Pump available for single or polyphase 50- or 60-cycle a.c. and d.c. operation. Bulletin W-323-B3.

Worthington Pump & Machinery Corp., Harrison, N. J.



INDUSTRIAL CLEANER

FOR industrial vacuum cleaning, blowing and spraying. Weighs 40 lb. As vacuum cleaner, dirt is drawn into 12-gal. aluminum finish steel tank where heavy dirt, metal, filings, turnings, etc., are deposited. Fine dust and dirt are drawn into dustproof bag. This

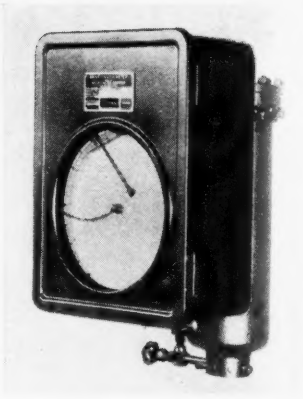


prevents heavy material from passing through fan and injuring blade, and permits collections in metal tank to be salvaged. Removable motor unit for quick changeover to blowing. Universal 1-hp. motor, either 110 or 250 volts, and 7-in. fan, to create vacuum of 46½ in. of water. When used as blower, fan delivers stream of dry air at nozzle 25,200 cu.ft. per min. Standard attachments include 10 ft. x 1½-in. flexible duck-covered hose, four types of nozzles, three different brushes, 46-in. steel extension handle and 20-ft. rubber extension cord with unbreakable rubber plugs. Also special attachments for cleaning furnace pipes, boiler tubes, flues, oven hearths, enamel and industrial ovens, hollow castings, and for spraying paint and other liquids. Bulletin.

Ideal Commutator Dresser Co., 1554 Park Ave., Sycamore, Ill.

FUEL FLOW-AIR FLOW METER

ENABLES operators of furnaces to maintain definite relation between air and fuel supplied to furnace, to insure highest combustion economy. Two recording pens, one showing rate of air flow or gas flow actuated by simple mechanical mechanism which receives motive power from differential pressure produced by fuel-line orifice. In a similar manner, second pen records flow of air for combustion. At time of meter installation, combustion test is made to determine proper ratio. Air-flow mechanism is then adjusted so that the records coincide one upon another when best combustion conditions are obtained. Operator therefore simply keeps the records of two pens together.



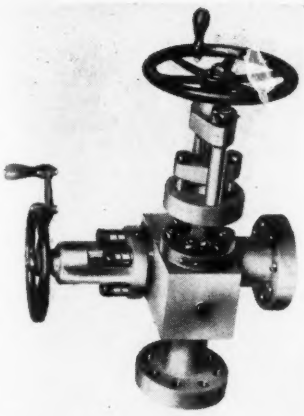
Unit also records and indicates rate of flow of fluid and total flow may be shown on 6-unit integrator. Pressed-steel casing for flush-front or surface mounting. Integrating mechanism requires a.c. with regulated frequency, although the meter may be furnished with a spring-driven clock recording mechanism if an integator is not desired. Auxiliary recorders of temperature or pressure may be included to record on the same chart with flow record. 12-in. diameter charts marked with direct-reading scales are uniformly graduated. Each record is different color.

Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

SMALL TUBE CLEANER

ROTO Junior air-driven cleaner for small tubes is self contained and has only two moving parts. Several cleaners can be operated simultaneously in same tubular apparatus. Will clean straight tubes as small as ⅝ in. o.d. and curved tubes with short-radius bends as small as ⅞ in. o.d. Used for small diameter tubes in condensers, heat exchangers, etc. Little headroom required and either horizontal or vertical tubes can be cleaned. Entire cleaner can be taken into condenser headers. Pressure 30 to 75 lb., air consumption 12 to 20 cu.ft. of free air per min. Bulletin.

Roto Co., 142 Sussex Ave., Newark, N. J.



FORGED-STEEL TANDEM BLOWOFF VALVE FOR H.P.

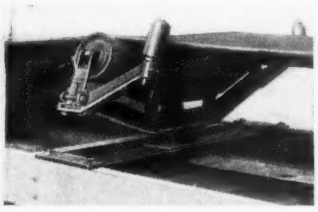
AVOIDS flanges, bolts and gaskets by using 1-piece forged steel billet as common body for both valves, with flanged forged-steel inlet and outlet nozzles screwed and welded in. Sealing valve is regular Yarway seatless design, blowing valve is new hard-seat type using special alloys to reduce wear. Made for 600 and 1,500 lb. pressure. Bulletin B-149.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

UNGRAPHITED PUMP PACKING

SPECIALLY for packing pumps handling foodstuffs, paper, pulp, etc., where graphite must not enter finished product, "Klero" packing has colorless, odorless and tasteless lubricant containing no graphite. Working sample in any size desired upon request.

Greene, Tweed & Co., 109 Duane St., New York, N. Y.



SELF-ALIGNING BELT CONVEYOR IDLER

"POSITIVE" self-aligning anti-friction idler for troughed conveyor belts train belt back automatically into a central position on carrying idler. Made up of standard belt-carrying rolls mounted in a supporting frame with arms extending parallel with and at sides of belt. Idler frame swivels promptly when crooked-running belt crowds sidewise enough to engage either idler. Troughing idler frame is supposed by anti-friction pivotal bearing, carried on a cross member or sub-frame bolted to conveyor stringers. Folder No. 1408.

Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

OIL-BLAST BREAKERS FOR PANEL MOUNTING

TYPE FK-43 oil-blast breakers for panel mounting require 35 per cent less floor space with increased reliability and reduced maintenance. Silver-to-silver current-carrying contacts prevent cumulative overheating, and new type solid-butt interrupting contacts will stand thousands of operations. Any mounting can be used, and breakers can be operated either manually or electrically. Rated 600 amp., 15,000 volts; 1,200 amp., 7,500 volts, with interrupting rating of 50,000 kva., at rated voltage. All three poles are inclosed in one frame and tank, saving inspection time and giving compact construction. Frame and tank are fabricated from steel plate with welded joints. Breaker mechanism internal type. Herkolite bushings. Eight instead of usual 13½ gal. of oil required. Complete line of accessories.

General Electric Co., Schenectady, N. Y.

NON-CORROSIVE CASTINGS

S MONEL, somewhat similar in analysis to Monel, but having higher maximum silicon content (3.75% max.), thus higher hardness and greater resistance to wear and erosion, particularly from steam. Non-galling, especially at high temperatures. Material as cast can be machined without difficulty if hardness is held to 325 Brinell by limiting silicon to 3%. Harder grades must be softened for machining, then heat-treated. Tensile strength 100,000 to 120,000 lb. per sq.in., yield point 90,000 to 100,000 lb. per sq.in. Another grade of Monel has hardness of 225 to 250 Brinell and silicon about 2.5%.

International Nickel Co., Inc., 67 Wall St., New York, N. Y.

THE ENGINEER'S BOOKSHELF

Parsons' Papers

SCIENTIFIC PAPERS AND ADDRESSES OF SIR CHARLES A. PARSONS (1935)—*Edited by G. L. Parsons. Published by Cambridge University Press and Macmillan Co., 60 Fifth Ave., New York, N. Y. 260 pages, 7x10½ in. Illustrated. Price $4.50.*

This memoir to the late Sir Charles A. Parsons is fittingly introduced by personal reminiscences written by Lord Rayleigh. The first part of the volume is devoted to papers and lectures dealing with the development and progress of the steam turbine. A second part contains lectures concerning artificial manufacture of diamonds, a research which occupied Sir Charles on and off for many years. The third part contains three appendices of which the last is a list of all Sir Charles' published writings. Parsons Auxetophone and optical glass are dealt with in the other two.

Mechanics and Heat

INTRODUCTION TO MECHANICS AND HEAT (1935)—*By Nathaniel H. Frank, Ass't Prof. of Physics, Mass. Inst. of Technology. Published by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 339 pages, 6x9 in. 140 diagrams. Cloth. Price $3.*

Designed originally for a basic course in technical physics, this text develops a logical and unified treatment of mechanics, acoustics and heat. An effort is made to avoid use of special formulas, so elementary calculus is employed from the outset. This is a book of principles; as such it should be used concurrently with a more descriptive text. Six chapters (about 60 pages) deal with heat problems directly and follow 16 chapters of mechanics and physics. Heat chapters are titled: Temperature and Thermometry, First Law of Thermodynamics, Heat Conduction, Thermodynamics and Kinetic Theory of an Ideal Gas, Properties of Real Gases, Second Law of Thermodynamics.

In addition to engineering college students, this book will be of interest and value to the engineer with a scientific turn of mind and some understanding of calculus who wishes to brush up on physical principles.

About Money

A PRIMER OF MONEY (*2nd Edition*). *By Donald B. Woodward, Moody's Investors' Service, and Marc Rose, editor of "The Business Week." Published by Whittlesey House, 330 West 42nd St., New York, N. Y. 322 pages, 5½x8 in. Cloth. Appendix, glossary and bibliography. Price $2.50.*

This is a new book with an old title, a revised and enlarged edition combining two earlier books, *A Primer of Money* and *Inflation*. Both have been brought up-to-date to include explanations of many of the puzzling monetary changes and theories that have come into prominence since 1932. Present operation of money and monetary systems is explained clearly and simply, and the birth, growth and development of money outlined. The book also shows the results of inflation in former times and in other countries.

A Primer of Money answers as plainly and simply as possible yours and my questions about money and credit without advocating anything. In fact, the authors go to extraordinary lengths to differentiate between what is theory and what is established fact. Further, they begin by assuming that the reader knows nothing at all about the subject; though this is improbable it at least rids us of those persistent misconceptions which are likely to make any study of the subject almost worthless.

This book is for the laymen—meaning most of us—who are awed and impressed by all these technical discussions and wordy battles that the real and self-styled economists are engaging in, who would at least like to know what it's all about before being projected into the midst of a conflict and asked to express an opinion or make a decision. It is for those of us who are forced to deal with money, credit, inflation and banking, and want to know at least enough to avoid an ignominious singeing.

Among the several chapters of additional material, Part IV, "The Present Crisis," is particularly noteworthy. There the authors have much to say about current theories and recent financial developments.

DEPT. OF SMOKE REGULATION, HUDSON COUNTY, N. J. 1934 ANNUAL REPORT. *27 mimeographed pages. Free*—An interesting report of this country's most progressive work (according to Dr. Hood, U. S. Bureau of Mines) on smoke regulation.

Rules for Long and Safe WIRE ROPE LIFE

How to select, store, handle, install and care for wire rope to insure good service

*By A. J. Morgan**
Chief Engineer, Wire Rope Division, John A. Roebling's Sons Co.

WIRE rope is a machine with many bearing surfaces. It belongs in the precision class, because its wires are held within a thousandth of an inch of correct diameter. It is not a bundle of wires thrown together in a haphazard manner, and should not be treated as if it were a load of reinforcing bars. It is surprising how much rope cost can be decreased and safety increased when reasonable care is given to the rope and equipment on which it operates.

When purchasing wire rope it is essential that it be of proper diameter, construction and quality. This is the first step in obtaining economical rope cost with safety. A great number of qualities and constructions from which to choose are available in ferrous and non-ferrous metals. Only where a sufficient number of ropes have been used to provide a reliable and safe history of operation will it be possible to specify with assurance the proper quality and construction. When a reasonable doubt exists it is advisable to put the problem up to the rope manufacturer, who from experience knows what the various qualities and constructions will do and is in a position to give sound advice.

There are instances when one construction and quality of rope shows somewhat longer life than another, but this may be at the expense of safe operation. Reliable rope manufacturers will not take advantage of the last bit of service if that must be gained at the expense of safety. Safety requirements vary on different installations and types of machines. One particular type of rope might be cheapest for a number of times and then a failure may result which will cost more than the previous savings. The statement that the cheapest material, as far as first cost is concerned, is not always the most economical is certainly true when considering wire rope.

It is very important that wire rope be stored in a dry place, kept off the ground, protected against the weather, direct sun, and excessive heat. Care should be taken to avoid corrosive gases or fumes, and materials which produce these fumes should not be stored in the same place with rope, neither should it be stored in a place where acid or similar corrosive substances have been kept. This may not seem of particular importance in so far as rope life is concerned, but it is surprising the number of cases of short rope life and dangerous conditions that result from improper choice of rope-storage space.

When ropes are stored for a relatively long time, they must be examined periodically to determine if additional lubricant is necessary to protect them. All wire-rope manufacturers attempt to put as much as possible of protective lubricant in the rope; unfortunately the lubricant or protector that will last indefinitely in general service has not been developed.

One important detail not given the attention that it should receive is the condition of the equipment or machine on which rope is used. When a new rope is to be installed, first inspect the equipment carefully for improper operating conditions. Short-service ropes and accidents can be avoided if this is thoroughly done and the equipment kept in good repair. Sheave-groove diameters should be examined to see that they will not pinch the new rope. They should be checked for roundness, because destructive vibration stresses are frequently caused by sheaves out of round or badly out of balance. Strange as it may seem, sheaves should be examined to see that they are turning on their bearings. Sheaves with broken flanges should be replaced, not only with rope service in mind, but safety dictates that this be done. On cranes where a side pull is made, often the rope catches in a broken flange and is badly damaged, sometimes being thrown off the sheave. It is also possible for ropes to be thrown off their sheaves where service conditions cause excessive vibration or whipping.

Examine Drums

Drums should be examined for unusual wear in the grooves. If plain-faced drums are used, examine them for grooves worn by the old rope, the pitch of which will probably not be sufficient for the new rope. Note if the flanges have been worn. This is particularly important if several layers of rope are wound on the drum. Places on equipment or machine where the rope has rubbed steel should be removed, or the rope held away from these points by sheaves, rollers or wooden bearing blocks. Generally wear of this character produces a groove smaller than the new rope, therefore, it might pull down into the groove and jam sufficiently to cause an accident. It will, at the least, reduce the life of new ropes.

It is easier and much less troublesome when proper rope installation methods are used. If space permits, it is advisable to lay short lengths of rope out on the ground. When this cannot be done and the rope is on a reel, it should be mounted as far away from the drum as possible and the rope reeved into position. When the rope is received in a coil, instructions for uncoiling should be followed. It is economical to handle rope properly because increased life will result.

Rope attachments should be of an approved type. Where the machine is self-contained, the manufacturer will use certain attachments as standard. Care should be taken to see that these are applied in the manner recommended.

After a new rope has been installed and all attachments made, run the machine light through a few cycles of operation to see if the rope is winding properly on the drum and that the equipment is functioning as it should. Frequently time is not taken to do this, with the result that the rope does not wind properly and cuts itself up due to unnecessary overwinding. This condition can be avoided by detaching the rope and allowing it to neutralize itself and then reattaching. Often, simply guiding the rope on the drum for the first few cycles of operation will start it winding properly. Ordinarily, however, if the installation has been correctly done and care taken to lay the rope out on the ground, even this will not be necessary.

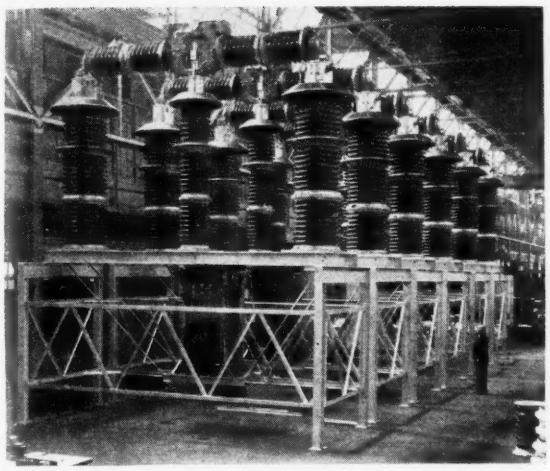
The Human Element

The human element is one of the most difficult variables to allow for in rope life. On one job quite a few years ago three identical cranes were doing apparently similar work and the operators were all experienced to about the same degree. Rope service on one crane was extremely variable, however, and the rope costs were high when compared with the others. When the cranes had been in service long enough it was also noticed that repair parts for this one particular crane were requisitioned much more frequently than for the others. It was decided that the operator was at fault and he was replaced. The service of the three cranes then became quite uniform. Such a condition not only seriously affected the cost of operation but also the safety of the crane.

Any set of rules for safe rope practice that is to be worthy of its name, must have as its basis the outside appearance of the rope. This surface inspection, in order to be a reliable and safe indicator, requires that the rope be protected against corrosion, which can best be done by thorough lubrication. Proper lubrication of wire rope is very important and too often is neglected. Unless rope lubrication is properly done, even the best rules for safe practice will be utterly valueless.

Several years ago two orders were received from different sources calling for the same size, type and quality of wire rope. The rope to fill both orders was made in one piece and then cut, placed on separate reels and shipped to the purchasers. One made a service record; the other caused a complaint for short service. Both of these ropes were identical in manufacture. The only reason for the difference in service was that one rope was properly taken care of, satisfactorily placed in service, and lubricated thoroughly, where the other was not stored in a good place and subsequent lubrication almost entirely neglected even though the rope had been properly installed. It is almost impossible to get some rope users to recognize that methods and practices which they have followed for quite a while are not necessarily the best.

*Abstract of a paper presented before the sixth annual Greater New York Safety Conference, March 6, 1935.



FAST AND BIG BREAKERS

Seven of the 24 single-pole circuit breakers being built at Philadelphia by General Electric for the Bureau of Power & Light, City of Los Angeles. Along the 270-mile, 287,500-volt line there will be eight breakers, each incorporating three of these poles. They will operate at a higher voltage than others, will interrupt the circuit in a little over ¼ the previous best time, need only 5% as much oil

POWER LINES

More Funds to HOLC To Guarantee Industrial Loans

Additional bonds totalling $1,750,000,000 are authorized for the Home Owners' Loan Corp. in legislation signed May 28 by President Roosevelt. Some of this money is available for underwriting or guaranteeing private loans to industrial plants for modernization, refinishing, etc., maximum loan on any project being $50,000. Operation of the HOLC had previously been curtailed due to shortage of funds. Applications will be received for only one month, closing June 27. Of the original $1,250,000,000 authorized to HOLC, $400,000,000 was allotted particularly for commercial building rehabilitation. This has all been allocated.

Business Papers Report Facts on National Problems

Governmental and business problems are analyzed in a series of printed reports issued by the Associated Business Papers, a non-profit organization of business publications whose readership runs well over 1,000,000 business men. Four reports issued to date cover: No. 1, Unemployment Compensation; No. 2 Old Age Security; No. 3, Thirty-Hour Week; No. 4, Security Act of 1933. The aim of these reports is to furnish reliable data for readers who wish to reach their own conclusions regarding the effect of various movements on their own businesses or jobs, and on the nation as a whole.

Readers of *Power* will perhaps be most interested in No. 3, "The Thirty-Hour Week," prepared by the Committee on Labor Relations and issuel April 15. This refers to the Black-Connery Bill, now before Congress.

Ths bill, making the 30-hour week mandatory in all industry, with certain exceptions, will, its supporters say, increase employment and total purchasing power, thus stimulate industrial activity, give security to wage earners, release credit in private business, lead to higher standards of living and wider demand for goods and services.

The following outlines the high spots of this A.B.P. analysis:

From 1900 to 1929, average weekly working hours in American industry were cut from 57 to 50, while per capita income increased 40%. Today's average is about 40 hr. Cutting to 30 hours with the same weekly wage would mean a 25% cut in hours and a 33% increase in hourly wage. This would directly increase manufacturing costs in varying degree, depending upon the percentage of labor cost in each industry. Additional labor cost would be buried in the cost of purchased materials.

National production in 1933 was valued at $42,800,000,000 and cost $46,800,000,000 ($4,000,000,000 net loss), of which $29,300,000,000 was spent for wages and salaries $9,600,000,000 for dividends, interest, rents and royalties, and $7,900,000,000 for the income of farmers and other self-employed individuals.

Reduction of hours to 30 would, the report predicts, produce a shortage of skilled workers in some lines, and the resulting influx of untrained men would further increase production costs. There would also be dislocations in certain industries that could not operate on 6 or 12 hr. daily and, at the same time, could not afford an additional shift.

Costs (and hence prices) will, the report says, increase faster than payrolls; hence the actual buying power of the wages of all previously employed will decrease. The farmer, particularly, will have to buy at higher prices with the same income. The higher prices (estimated average increase of 25%) will also cut our export trade.

The net result, the report continues, would be the bankrupting of many concerns now operating on a close margin. Finally, reduced sales would force a reduction both in wages and employment. Thus, according to the report, passage of the Black-Connery Bill may be expected to damage both business and labor and to retard recovery.

Copies of any of these reports may be obtained from the office of the Associated Business Papers, 330 West 42nd St., New York.

Engineers Urge $50,000,000 for Plans and Surveys

In an all-day meeting in the Hotel Roosevelt, New York, May 18, the New York State Society of Professional Engineers passed a resolution urging the national administration to allocate $50,000,000 of the new $4,000,000,000 recovery fund for surveys, plans and studies to be made by established engineers on a normal salary and fee basis. This, the resolution stated, would avoid the economic waste of unplanned projects. Another resolution urged the abandonment of present relief methods and the substitution of contract work on all projects involving more than $10,000.

More than 600 engineers attended the luncheon, which was addressed by David B. Steinman, president of the National Society of Professional Engineers, John Charles Riedel, incoming president, and others. Linford S. Stiles presided, and Arthur Sheridan, past president, was toastmaster.

Mr. Steinman stressed the importance of the national society, and pointed to the rapid extension of professional engineer licensing to new states in recent months.

New officers elected were:

John Charles Riedel, president; Alfred E. Roche, 1st vice-president; Fred H. Zurmuhlen, 2nd vice-president; Ernest F. Fox, financial secretary; Patrick M. Corry, treasurer.

The following new directors were elected: John Avery, Charles W. Burke, Joseph F. Lamb, Elmer C. Lawton, John L. Scanlon, Ole Singstad, Edward E. Stickney, Walter H. Weiskopf, Linford S. Stiles, James A. Pietsch.

Engineers Study Feed-Water Chemistry

Starting May 8, and meeting at the Robert Treat Hotel, Newark, N. J., on six consecutive Wednesdays, more than 200 engineers are attending a series of lectures on "Chemistry of Water Correction," presented by W. H. & L. D. Betz, chemical engineers, Philadelphia. These lectures, first given in Philadelphia in the fall of 1934, cover general chemistry, water chemistry and water analysis, with particular reference to the problems of boiler water and boiler scale and constant attention to scientific fundamentals.

EEI Convention Covers Economic Aspects

June 3 to 6 at Hotel Traymore, Atlantic City, N. J., Edison Electric Institute held its third annual convention. The program was planned to present subjects of paramount interest and value to the electric light and power interests, its customers and stockholders. Most of the papers emphasized phases of utility operations and competition of direct public concern. Maximum economy in system design consistent with adequate and reliable service, government competition in its various ramifications, and successful sales promotion had prominent places on the program. Even the papers on subjects generally regarded only in their purely technical aspects dealt with economic and social factors.

Papers of greatest interest to engineers are "Effects of Service Standards on System Design," by N. E. Funk, vice-pres., Philadelphia Electric Co., and "Plant Modernization," by Marion Penn, general manager, Public Service Electric & Gas Co. The latter deals primarily with improvement of existing plants and shows that a large percentage of present capacity can be brought to high efficiency.

COMING MEETINGS

American Gas Ass'n—Annual convention, Oct. 14-18, Atlantic City, N. J.

American Institute of Electrical Engineers — Summer convention, Ithaca, N. Y., June 24-28. H. H. Henline, national secretary, 33 West 39th St., New York, N. Y.

American Society of Heating & Ventltg. Engrs.—Semi-annual meeting, Royal York Hotel, Toronto, Ont., June 17-19. A. V. Hutchinson, secretary, 51 Madison Ave., New York, N. Y.

American Society of Mechanical Engineers — Semi-annual meeting, June 19-21, Cincinnati, Ohio. C. E. Davies, secretary, 29 West 39th St., New York, N. Y.

American Society for Testing Materials—38th annual meeting, Book-Cadillac Hotel, Detroit, Mich., June 24-28 (exhibit at same time). R. E. Hess, assistant secretary, A.S.T.M., 260 S. Broad St., Philadelphia, Pa.

American Welding Society—Fall meeting in conjunction with National Metals Exposition, Chicago, Ill., Sept. 30. W. Spraragen, secretary, 29 West 39th St., New York N. Y.

Canadian Electrical Ass'n—45th Annual convention, Algonquin Hotel, St. Andrews-by-the-Sea, N. B., June 26-28. Offices Room 408, Power Bldg., Montreal, Que.

Ass'n of Iron & Steel Electrical Engineers — Annual convention and exposition, Wm. Penn Hotel, Pittsburgh, Pa., Sept. 24-26. Headquarters, 1010 Empire Bldg., Pittsburgh.

15th Exposition of Chemical Industries—Grand Central Palace, New York, N. Y., Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

Great Lakes Power & Mech'l Exposition—June 24-28, on Steamer "Seeandbee," starting from Cleveland. Ernest H. Smith, managing director, 3910 Carnegie Ave., Cleveland, Ohio.

National Ass'n of Power Engineers—Annual convention, Wm. Penn Hotel, Pittsburgh, Pa., Aug. 26-30.

National District Heating Ass'n—Annual convention, June 11-14, Bellevue-Stratford Hotel, Philadelphia, Pa.

7th Midwest Power Show—Chicago, Ill., Oct. 14-18. G. E. Pfisterer, managing director, 1 North LaSalle St., Chicago, Ill.

A.I.E.E. to Hold Summer Convention

A program replete with activities for engineers has been arranged for the 59th annual summer convention of the American Institute of Electrical Engineers, at Cornell University, Ithaca, N. Y., June 24 to 28. A number of technical papers having to do with recent developments will be presented at 10 technical sessions. Papers of particular interest to power engineers are those on An Improved Electrothermic Instrument, by Paul M. Lincoln; Engineering Features of Boulder Dam, by L. N. McClellan; Design and Operation of Huntley Station No. 2, by H. M. Cushing; Rehabilitation of the Connors Creek Power Plant, by R. E. Greene; Sparking Under Brushes of Commutator Machines, by R. E. Hellmund and L. R. Ludwig; Time-Temperature Tests to Determine Machine Losses, by M. D. Ross; Circuit Breakers for Boulder Dam Line, by D. C. Prince; D.-C. Braking of Induction Motors, by F. E. Harrell and W. R. Hough; Electric Power Equipment for Steel Plants, by R. H. Wright; D.-C. Circuit Breakers in Steel-Mill Service, by William Deans; Storage Battery Charging, by J. L. Woodbridge; and, Some Features of the Boulder Canyon Project, by E. F. Scattergood.

A number of technical conferences or informal round-table meetings on various subjects have been scheduled for the benefit of specialists and the younger members. Subjects to be discussed at these conferences include: D.-C. Test Code, by R. W. Owens; Transformers, by J. E. Clem; Noise, P. L. Algers; Mercury-Arc Rectifiers, by O. K. Marti; Circuit Breaker Standards, by H. P. Sleeper; and, Distribution-Transformer Protection, by K. B. McEachron.

Group Drive Tours Country

To demonstrate possibilities of modern group drive, the Power Transmission Council, sponsored by the Mechanical Power Engineering Associates, 370 Lexington Ave., New York, N. Y., has equipped a truck with four electric generators driven as a group by a single motor, and four similar generators driven by individual motors. Provisions are made to measure accurately power input and output for each system of driving. The itinerary will include practically every Power-Transmission-Club city in the United States and Canada this year and several important expositions.

Government to Build Quoddy Project

May 16, the Advisory Committee on Allotments approved 47 Federal work-relief projects to be supervised by the Army Corps of Engineers. Along these is the Passamaquoddy Bay tidal-power development, Eastport, Me. The original project, proposed by Dexter P. Cooper, included Passamaquoddy Bay, a large part of which is in Canada. As now proposed, and as shown on the map, the project is entirely in the United States and includes a tidal-power plant for a maximum head of 18 ft. in Cobscook Bay, in combination with a pumped-storage hydro-electric installation for a 130-ft. head.

The initial development will utilize the head above 5 ft. in a main tidal-power station with an installed capacity of 166,670 kva., but the power house will be built for a maximum capacity of 366,874 kva., with 12 units not installed. The estimated cost is placed at $36,284,000.

In Cobscook Bay, normal tide range is 18 ft. where the emptying gates will control pool level. To construct the navigation locks for this pool will require a cofferdam 75 ft. deep capable of standing a maximum tidal range of 20 ft. and ocean storms. Three of the rock dams are to be placed in water over 100 ft. deep, subjected to the high velocity due to periodic reversing of the tide.

Major Philip B. Fleming, of the Corps of Engineers, is to be engineer in charge.

District Heating Ass'n to Meet

National District Heating Ass'n will hold its 26th annual convention, June 11-14, at the Hotel Bellevue-Stratford, Philadelphia, Pa. A number of papers are scheduled of particular interest to *Power* readers and will be reported in the July number. They include such subjects as: cinder elimination, laying up boilers, pipe expansion, temperature control, calculation of steam usage, consumption of steam in college buildings, hot-water distribution, relative corrosive effects of various gases in condensate, steam-jet refrigeration.

Floating Power

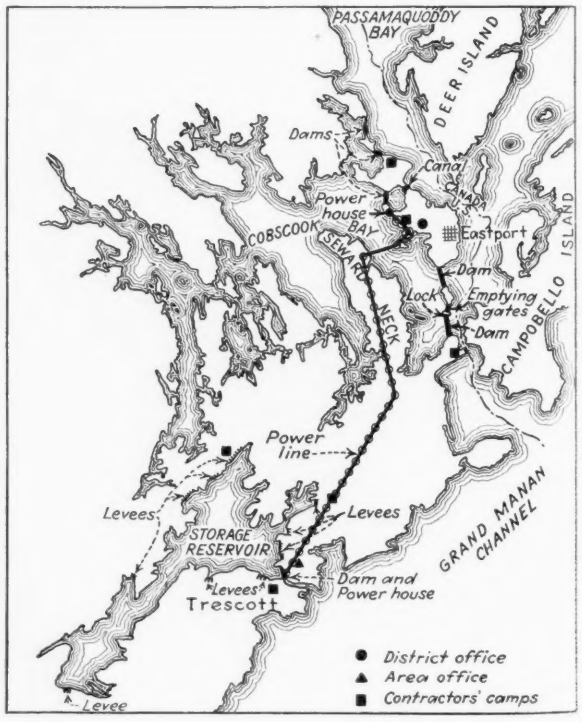
French Line's new luxury liner "Normandie," which arrived in New York on her maiden voyage June 3, is driven by some of the most powerful marine engines in the world. This giant ship is driven by electricity derived from 29 oil-fired water-tube boilers which supply steam at 400 lb. per sq.in. pressure and 666 deg. F., developing 160,000 hp. and driving four turbo-alternators.

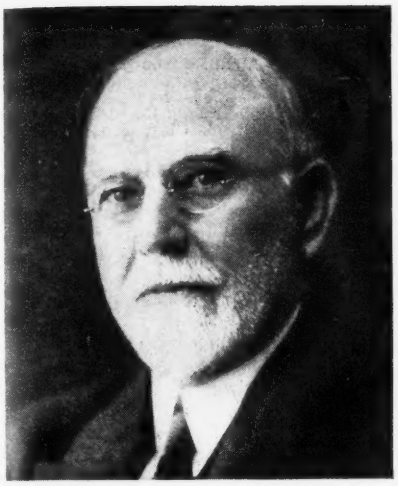
The turbines are of the multicellular type with 19 stages. Disks are nickel-chromium steel, and blading is ATV. Generators power four synchronous motors, each driving a propeller shaft. For lighting, elevators, and other auxiliary electrical equipment, the "Normandie" has six 2,200-kw., 220-volt D.C. turbo-dynamos.

For the condenser tubes, 70/30 cupro-nickel alloy is used, some 19 tons of this metal being used.

New York Studies Smoke

A six months' day-by-day study of atmospheric conditions in New York City is to be made by the Emergency Relief Bureau under the direction of the Health Department 190 engineers and observers will be employed.





McGraw Honored for 50 Years Publishing Leadership

Highspot at the annual Spring conference of the Associated Business Papers at Hot Springs, Va., May 4-5, was a testimonial dinner to James H. McGraw, chairman of the board of directors of McGraw-Hill Publishing Co., Inc., in honor of his fifty years' service in publishing. Spokesmen of A. B. P. extolled Mr. McGraw for his leadership, achievements, and personal qualities. Following this, a testimonial scroll and watch were presented to him, on behalf of the Association. Charles Stark, president of Penton Publishing Co., presided at the dinner.

In replying to the honors paid him, Mr. McGraw outlined the publishing philosophy he had developed in the last half century.

"In my opinion," he said, "the function of the business paper is (1) to advance the status of the industry it serves, and (2) to supply the individual members a specific knowledge concerning the industry. The first represents the new function, one which has become necessary within the last fifteen years.

"In fulfilling function one," he said, "which is really a leadership job, the business paper requires a new relationship to its field different to that it bore when it was primarily a teacher. It becomes both a protagonist and a critic of its industry. The former role is easy, the latter one is a real job. It is necessary to differ with one's industry from time to time. This necessitates guarding against a bumptious editorial attitude, but at the same time sticking to one's guns.

"There is still another new and vitally important function of the business press," Mr. McGraw pointed out in his talk, "That is to keep its readers informed as to the effect of the broader economic forces on their own business and to interpret these as well as political and governmental action as it affects their business. This new responsibility of the business press is a direct result of the economic chaos which followed the World War."

ASTM Plans 38th Meeting

The American Society for Testing Materials is holding its 38th annual meeting at the Book-Cadillac Hotel, Detroit, June 24-28. Included in the many papers and reports at the meeting is an address by C. F. Hirshfeld of Detroit Edison on "Relation of Specifications to the Engineering Profession," and reports of the committees on refractories, classification of coals, corrosion of iron and steel, corrosion testing, corrosion of pipe, etc. There will be an exhibit of testing equipment.

Boiler Inspectors Meet

The National Board of Boiler and Pressure Vessel Inspectors held its tenth annual meeting in Stevens Hotel, Chicago, May 14-17. Included in the papers were these of particular interest to power engineers: Statistical Analysis of Boiler Accidents as a Means of Improving Experience, Construction and Strength Characteristics of Laminated-Wall Pressure-Vessel Construction, Test of Physical Properties of Welds, A.S. M.E. Interpretations for Shop and Field Practice, Protective Methods of Minimizing Hazards in Operation of Refrigerating Systems, Use of Alloy Steel for Temperatures over 800 Deg. in the Construction of Boiler Drums Superheaters and Steam Pipes, Water-Wall Failures, Bent-Tube Boiler Failures, Non-Destructive Examinations of Welded Joints, New Ferrous Materials for High-Pressure Boilers and Pressure Vessels, Experiences with Boilers at Pressures above 1,000 Lb. Welding High-Pressure Steam Pipe.

Air-Conditioning Manufacturers

More than 40 representatives of leading air-conditioning equipment manufacturers met at Hot Springs, Va., May 23, for a discussion of policies and a report on progress in their studies on air-conditioning standardization. The newly elected board of directors is composed of: C. T. Morse, American Blower Co.; Thornton Lewis, Carrier Engrg. Corp.; H. C. Grubbs, DeLaVergne Engine Co.; W. F. Armstrong, Frigidaire Corp.; J. J. Donovan, General Electric Co.; J. A. Harlan, Kelvinator Corp.; S. J. Meyers, Westinghouse; Stuart E. Lauer, York Ice Machry. Corp. P. A. McKittrick, Parks-Cramer Co., was elected president and J. F. G. Miller, B. F. Sturtevant Co., vice-president of the association.

N. Y. State N.A.P.E. Holds 40th Convention

With Victoria Hotel, 51st & 7th Ave., New York, as headquarters, New York State National Association of Power Engineers will hold its 40th Annual Convention, June 14 to 15. G. Griffel, chief engineer, Victoria Hotel, is chairman. A power-equipment exhibition will be held in the hotel.

ASHVE Meeting

Papers of particular interest to power engineers in the program of the Semi-Annual Meeting of the American Society of Heating & Ventilating Engineers in Royal York Hotel, Toronto, Ont., June 17-19, include: Cooling and Air Conditioning and Ale Brewery, Design and Operation of the Heating Systems at Mt. Holyoke College, Study of Air Filters, All-Electric Heating and Cooling.

OBITUARIES

CHARLES H. CLARK, 66, formerly operating steam engineer of U. S. Veterans' Hospital, Northampton, Mass., died suddenly in Boston May 17.

THEODORE W. KIRKLAND, 69, president of Holyoke (Mass.) Belting Co., died in Holyoke May 25. He had been connected with Page Belting Co., Concord, N. H., and Norwich (Conn.) Belting Co.

R. L. KERR, chief engineer, C. H. Wheeler Mfg. Co., Philadelphia, Pa., died April 23. He had been connected with the company for the past 20 years.

C. F. LACOMBE, 70, chief engineer of light and power for the City of New York from 1903 to 1915, died in Babylon, N. Y., May 26. While employed by New York City Mr. Lacombe had charge of all its gas and electric work and contracts, brought together all the light, power and inspection bureaus into one organization, and was responsible for expenditures of $6,000,000 a year.

PERSONALS

SHEPPARD T. POWELL, author of the article "Chemical Deaeration of Boiler Feed Water," in this month's *Power*, has resigned as chairman of the Boiler Feed Water Studies Committee, American Water Works Association, a position which he has held since inception of the studies about ten years ago. C. H. Fellows, of Detroit Edison Co., has been elected chairman and C. H. Bardwell, Chesapeake & Ohio Railway, as vice-chairman. Mr. Powell will remain as a member of the executive committee.

HERBERT J. WINN, president of Taylor Instrument Companies, Rochester, N. Y., sailed from New York May 15 on the *Aquitania* for London on a 5-week business trip.

FRANK T. HITCHCOCK, head of the purchasing bureau of the Edison Electric Illuminating Co. of Boston since 1929, and formerly a vice-president of the Metropolitan Coal Co. there will retire July 1. He is widely known in power engineering circles, and during the world war was a member of the fuel commission. Sidney Hosmer, vice-president and general manager of the Edison company, long actively idenitfied with its fuel purchasing problems, will become acting head of the bureau.

HENRY E. WARREN, president of Warren Telechrone Co., Ashland, Mass., will receive the 1934 Lamme Medal of the A.I.E.E. for his outstanding contribution to the development of electric clocks and means for controlling central station frequency. Franklin Institute is also giving him the John Price Wetherill Medal in recognition of his invention of the Telechron motor.

CONNERY & CO., INC., 2nd & Luzerne Sts., Philadelphia, Pa., has been reorganized as Connery Construction Co., with the same officers and at the same location. The new company will fabricate and erect breechings, uptakes and air ducts and engage in general construction and repair of steel plate work such as tanks, hoppers, bunkers, standpipes and chutes.

ALLEN-BRADLEY CO., Milwaukee, Wis., has added Claude O. Sargent to its Philadelphia office. Robert McGarry, 807 Rose Place, Utica, N. Y.; Bjorn Hanson, 306 Canedy St., Springfield, Ill.; R. B. Soderberg, 196 Palm St., Hartford, Conn.; and W. J. Hess, 912 First Ave., Charleston, W. Va.; have also taken over sales work.

Developed and Potential Water Power of the World

Capacity of the water wheels in plants of the world, according to estimates made by the United States Geological Survey, Department of the Interior, was 23,000,000 hp. power in 1920, 29,000,000 hp. at the end of 1923, 33,000,000 hp. at the end of 1926, 46,000,000 hp. at the end of 1930, and 55,000,000 hp. at the end of 1934, an increase of nearly 140% in 14 years.

Potential water power of the world is given as 472,000,000 hp., divided as in the table:

Areas	Potential Hp.	Developed Hp.
Africa	190,000,000	115,000
Asia	80,000,000	4,900,000
Europe	58,000,000	24,300,000
North Am.	73,000,000	24,400,000
South Am.	54,000,000	1,000,000
Oceanica	17,000,000	550,000
U. S.	42,000,000	16,075,000
Canada	18,000,000	7,547,000
Brazil	25,000,000	700,000
Italy	3,800,000	5,800,000
France	5,400,000	4,300,000
Germany	2,000,000	2,800,000
Switzerland	2,500,000	2,350,000

Europe has practically caught up to North America in installed capacity of water wheels, but proposed installations at such plants as Boulder, Norris, Bonneville, and Grand Coulee greatly exceed anything under construction anywhere else in the world. The large increase over previous estimates in developed power in France is due partly to the fact that the previous estimates were based on power available at medium and low stages, whereas the present estimate is based on installed capacity of water wheels.

These estimates are based on information available in the United States Geological Survey, and for many countries the figures for the capacity of installed water wheels are based on data collected a year or more ago.

Estimates of potential water power are based on ordinary low water and an efficiency of 70% in the plants.

In comparing these estimates of potential power with those for developed power, allowance should be made for the fact that the latter are based on the installed capacity of machinery at constructed plants, which averages two or three times the potential power at low flow at the same sites. In such countries as Germany, France and Switzerland allowance must also be made for the large capacity installed in pumped-storage plants.

German Foreign Trade in Diesels in 1934

Report dated March 14, 1935, by American Vice-Consul James H. Wright, Cologne, Germany.

German foreign trade in Diesel engines was irregular in 1934, despite a small increase in the total value of export shipments. An increase in the value of foreign sales is evident only for the water-craft group, shipments of other types, which constitute by far the principal portion of the total, having shown a drop in 1934 as against the previous year. Total export sales were:

Many important foreign purchasers of diesels for other than water craft uses were absent as buyers in 1934. In this connection particular mention should be made of France, Italy, Yugoslavia, Russia, Egypt, China, Japan, the United States, Colombia, and the Dominican Republic. On the other hand, augmented commitments were made by Belgium, Greece, the Netherlands, Spain, British India, Palestine, the Philippine Islands, Argentine, and Brazil.

German Diesel Exports	1933 Quantity Metric Tons	1933 Value Reichsmarks	1934 Quantity metric Tons	1934 Value Reichsmarks
Diesels for otherthan water-craft use	7,709	13,690,000	8,308	12,890,000
Diesels for water-craft use	1,853	4,029,000	2,721	6,377,000
TOTALS	9,562	17,719,000	11,029	19,267,000

STRAWS

Pointing the way business winds blow

Morris, Minn., has taken bids for municipal power plant, and will proceed with work as soon as a bond issue of $150,000 has been approved. Special election called June 18. Fairbanks, Morse & Co., Chicago, Ill., has tendered a low bid for generating machinery and accessory equipment at $92,585; West Central Construction Co., Wheaton, Minn., is low bidder for power house contruction at $26,463; Donovan Construction Co., St. Paul, Minn., has submitted low figure for construction of a municipal electrical distribution system at $53,488. A total fund of $188,000 will be available, part a Federal grant. Burlingame & Hitchcock, Sexton Bldg., Minneapolis, Minn., consulting engineers.

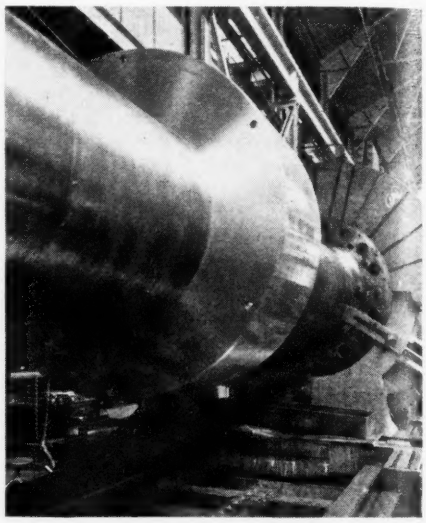
Construction Service, Veterans Administration, Washington, D. C., plans early construction of an underground electrical distribution system at institution at Hampton, Va., to cost about $75,000. A similar installation is proposed at institution at Excelsior Springs, Mo., to cost approximately $100,000, and for which bids are scheduled soon. Bids are being asked until June 18 for installation of a new water-softening system at institution at North Chicago, Ill.

Fort Smith, Ark., will receive bids until June 17 for a new water supply system, estimated to cost $1,650,000, in which amount financing has been arranged. Also power station unit, with hydraulic turbine-generator set and standby oil engine-generator pumping machinery and complete accessories; new 27-in. welded steel pipeline. W. R. Holway, 302 East 18th St., Tulsa, Okla., consulting engineer.

Fort Collins, Colo., will take bids, closing about the middle of June, for equipment for municipal electric power plant, including two 1,500-kw. steam turbo-generator units with accessories, steam generating units, etc. Fund of $740,000 has been arranged. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, Mo., consulting engineer.

Dyer, Tenn., plans construction of a municipal electric power plant. State Legislature has passed an authorizing bill.

Public Works Officer, Mare Island Navy Yard, San Francisco, Calif., plans extensions and improvements in electric lines. Bids soon. Fund of $120,000 being arranged.



FOR BOULDER DAM

Second of the 82,500-kva. generators for Boulder Dam is now being built in Schenectady by General Electric. The main shaft for the generator, shown being shaped on a lathe, is more than 36 ft. long, 5½ ft. in diameter at the widest part, and weighs 108,000 lb. When shipped, it will be a carload by itself

Cortez Oil Co., Trinity Life Bldg., Fort Work, Tex., plans early construction of new 6-in. welded steel pipeline from recently opened Samfordyce oil fields, in Southern part of Hidalgo County, Tex., to Port Isabel and Brownsville, Tex., about 85 miles, for crude-oil transmission to latter points. Facilities for daily capacity of about 700 bbls. Cost close to $500,000.

Imperial Irrigation District, El Centro, Calif., is planning for early construction of a new hydroelectric power plant on the All-American Canal. Fund of $13,500,000 proposed for entire project, arranged through Federal aid. M. J. Dowd is chief engineer.

Cushing, Okla., has awarded contracts for new municipal electric light and power plant, and will proceed with construction at once. Entire project will cost about $340,000. Mattison-Wallack Co., Key Bldg., Oklahoma City, Okla., has secured award for three 750-hp. diesel engine units with accessory equipment at cost of $137,867; Forney Engrg. Co., Dallas, Tex., will furnish generator sets, transformers, motors, switchboard and auxiliary apparatus, and station wiring on bid of $25,509.42; power station building, warehouse, cooling tower and soft water cistern will be constructed by Charles M. Dunning, Oklahoma City, at a cost of $47,879. Mattison-Wallack Co. has also secured contract for installation of a complete electrical distribution system at $93,922. W. R. Holway, 302 East 18th St., Tulsa, Okla., consulting engineer.

U. S. Naval Academy, Annapolis, Md., plans extensions and improvements in electric systems, estimated to cost $163,000, with equipment; similar program is proposed in connection with the sanitation and ventilation systems, estimated to cost $130,000, and for power, heating and refrigeration facilities. Appropriations in amounts noted are being arranged. Bids will be asked in near future by Bureau of Yards & Docks, Navy Department, Washington, D. C.

Murray, Ky., is considering plans for new municipal electric plant. Proposed to arrange financing through Federal aid.

Glencoe, Minn., will soon select an engineer to make surveys and estimates of cost for a proposed municipal electric plant, including complete distribution system. Financing will be determined later. F. X. Eickmann, city clerk, in charge.

Spokane, Wash., has plans for a hydro-electric plant to be operated in conjunction with upriver waterworks pumping plant. Project will include a power dam, power house and transmission line, and is estimated to cost $625,000. City has rejected a Federal loan proposal and will finance through a bond issue of $470,000 and a Federal grant.

Platte Valley Public Power & Irrigation District, North Platte, Neb., Donald D. Price, chief engineer and business manager, is making call for bids in connection with hydro-electric power and irrigation project, for which a fund of $7,500,000 has been secured through Federal aid. Active purchase of materials and equipment will be made during the next 60 to 90 days. Allied Bridge & Construction Co., Wahoo, Neb., has been awarded contract for one of main power plant buildings near Sutherland, Neb., and work on unit (known as Contract 20), will begin soon; Bushman Construction Co., St. Joseph, Mo., has award for tailrace structure at $29,039. Parsons, Clapp, Brinckerhoff & Douglas, 142 Maiden Lane, New York, consulting engineers.

Lyles Ford Tri-County Authority, L. G. Young, Union, S. C., chairman, has plans under way for new hydro-electric power project on Lyles Ford, to furnish electric service in Union, Newberry and Fairfield Counties. Three power dams will be built. Project to cost $13,214,000, and application for loan has been made to PWA. It is expected to begin work as soon as financing has been completed.

Shawano, Wis., has authorized plans for extensions and improvements in municipal electric plant, including new equipment. To ask bids soon. Auler, Jensen & Brown, Oshkosh, Wis., architects.

Rock Rapids, Iowa, is considering construction of new municipal electric plant. Proposed to arrange a fund of about $150,000 for project. W. F. Gingrich, Superintendent of Public Utilities, in charge.

Bethlehem Steel Co. has purchased $1,250,000 worth of motors, control and power equipment for its Lackawanna plant, at Buffalo, N. Y., from Westinghouse. Included are four 3,000-hp. and one 1,000-hp. a.c. motors, nine 1,250-hp. d.c. motors and one 2,500-kw. and one 1,300-kw. motor-generator sets, as well as 800 smaller motors.

Danville, Va., has received a $2,750,000 loan and grant for a hydro plant on Dan River. Taxpayers have not yet accepted it, in fact voted against it a year ago.

Alameda, Calif., courthouse is being air-conditioned by Westinghouse through E. B. Ward & Co. This is the first large complete installation of its type in the San Francisco Bay area.

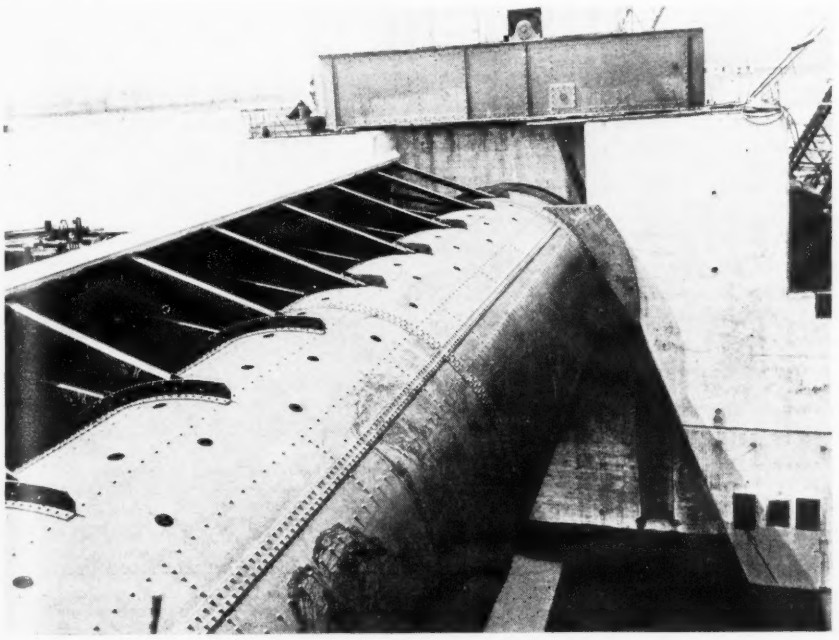
U. S. Indian Service, Dept. of Interior, Washington, D. C., will begin immediate construction of a new standby electric generating station near Coolidge, Ariz., for which an appropriation of $261,000 has been made. Station will be of diesel generator type, and contract for prime movers has been awarded to Nordberg Mfg. Co., Milwaukee, Wis., at a cost of about $164,000. Initial plant will have a rating of 2,600 hp., with provision for installation of additional equipment for increased output in future. The plant will be used primarily for auxiliary service, to operate a series of deep-well pumps for irrigation purposes, augmenting the water supply from the San Carlos reservoir during the peak irrigation season.

Michigan Carton Co., Battle Creek, Mich., plans early construction of a new boiler house, including 50-ft. steel stack. Cost about $75,000, of which more than half will be expended for boilers and accessories, feed-water pumps and other equipment. Shreve, Anderson & Walker, Book Bldg., Detroit, Mich., architects.

Baltimore, Md., plans extensions and improvements in municipal water system to cost $6,054,000, financing through Federal aid. Project will include new pumping plants, with high-pressure and medium service pipe lines, installation of new metering equipment at Montebello filter station, new reservoirs and other facilities. Water Bureau will be in charge.

Wisconsin Rapids, Wis., has approved plans for extensions and improvements in municipal electric power plant, including remodeling of present unit, and expects to proceed with program in June. Additional equipment will be installed. Hougen & Henderson, Wisconsin Rapids, architects.

Olson Rug Co., Chicago, Ill., is planning a power plant and factory addition to cost $400,000, the power plant itself to cost $150,000 and to replace purchased power. The power plant will incorporate coal and ash towers, sprinkler-type stokers, steamatic ash conveying, flow-type dustless coal conveyors, and will operate at 275 lb. and 200 deg. superheat. Weiss & Niestadt, architects & engineers; John Small, consulting engineer, Edmund Higginson, mechanical engineer.



GIANT HEATING UNITS FOR MISSISSIPPI DAM

Giant Calrod units are being built by GE for this dam near Canton, Mo. Gates are of the roller type, some 109 ft. long and 20 ft. in diameter, and the heating units are required to keep them free of ice in winter

West Kootenay Power & Light Co., Ltd., has started a new 20,000-hp. substation at Tadanac, B. C. A 12,000-hp. substation is planned at Stoney Creek. All work is being done by the company.

Spring Valley, Minn., will take bids in June for a new municipal electric light and power plant, using diesel generator units, including distribution system. A fund of $110,000 has been arranged. G. M. Orr & Co., Baker Bldg., Minneapolis, Minn., consulting engineers.

Federal Loans and Grants for Municipal Plants

The following Federal aid projects have been authorized during the past month, covering loans and grants for electric power plants, water pumping stations, pipe lines, etc. Work is scheduled to be placed under way at early date.

POWER

Lodi, Calif., $600,000 for municipal hydro-electric plant on Mokelumne River, with initial capacity of 1,375 kva., including 27-mi. transmission line. F. C. Herman, Merchants' Exchange Bldg.; Walter L. Huber, Crocker First Natl. Bank Bldg.; and Nelson A. Eckart, 425 Mason St., all San Francisco, consulting engineers.

Winnemucca, Nev., $35,000 for power plant and waterworks.

Islip, N. Y., $75,000 for electric power plant.

Dover, Ohio, $225,000 for extensions and improvements in municipal power plant, including new steam turbine unit, high-pressure boilers, stokers, condensers and accessories, and $59,000 for electrification of waterworks pumping station.

Edgerton, Ohio, $60,000 for new electric generating plant.

Frederick, Okla., $136,000 for electric power plant. Plans have been prepared by V. V. Long & Co., Colcord Bldg., Oklahoma City, Okla., consulting engineers.

Bethlehem, Pa., $115,000 for new electric generating plant.

Plainview, Tex., $423,346 for municipal electric power plant and distribution system.

PUMPING & WATERWORKS

ALABAMA—Carrollton, $27,000; Childersburg, $39,000; Frisco City, $35,000; Hackleburg, $30,000; Madison, $24,000; and Oakman, $32,000.

ARKANSAS—Lewisville, $14,000.

CALIF.—North Sacramento, $132,000; Victorville, $59,000.

FLORIDA—New Smyrna, $80,000.

IDAHO—Bloomington, $34,000; Victor, $20,000.

ILLINOIS—Bunker Hill, $92,000; Du Quoin, $466,000, including sewage system and station; Enfield, $41,000; Marissa, $83,000; Raymond, $52,000; Rochester, $33,000; and Troy, $32,400.

INDIANA—Milltown, $14,500; South Bend, $400,000.

KENTUCKY—Cumberland, $97,000; New Haven, $32,000.

MICHIGAN—Bear Lake, $22,000; Minden, $21,000; Mount Morris, $30,000.

MINNESOTA—Grand Marais, $88,000.

MISSOURI—Oak Grove, $51,000. . . . . .

MONTANA — Chinook, 24,000; Bainville, $34,000; Helena, $826,000 for irrigation project.

OHIO—Jackson Center, $27,500; Springfield, $370,000.

OREGON—Columbia County, $15,000 for pumping plant only; Coquille, $35,000; Empire, $10,000; Mosier, $14,000; Tillamook, $77,600; Wallowa, $62,000; Willamina, $16,000.

PENNA.—Smithfield, $45,000.

TENNESSEE — Hartsville, $57,000; Savannah, $59,000.

TEXAS—Bogota, $73,000; Tom Bean, $20,000; Windom, $22,000.

UTAH—Torrey Town, $17,000.

VIRGINIA—Stanley, $23,000; Washington County, $428,000; Buchanan, $66,000.

WASHINGTON—Almira, $21,000; Mabton, $42,000; Marysville, $57,000; Omak, $18,000; Ridgefield, $21,000; Sultan, $20,000; Tacoma, $43,000.

WYOMING—Big Horn, $1,108,000 for irrigation project.

NEW BULLETINS

Pipe Flanges — Taylor Forge & Pipe Works, Chicago, Ill. 96-page catalog 35, "Forged Steel Pipe Flanges" on design and specification of pipe flanges. Includes prices and dimensions and fittings for welding.

Feedwater Regulators—Stets Co., Inc., 141 Milk St., Boston, Mass. Description of this company's feedwater regulators in zincographed booklet.

Steam-Jet Refrigeration Standards—Carbondale Machine Co., Harrison, N. J. Bulletin W.207-E17 describes new standards on steam-jet refrigeration developed by Standards Committee appointed by Vacuum Cooling and Steam Ejector Section of Heat Exchange Institute.

Centrifugal Pumps—Worthington Pump & Machinery Co., Harrison, N. J. Three new bulletins: Worthington Monobloc Centrifugal Pumps, Types DE, DF and DG, described in 4-page bulletin W-321-B4. Also 4-page Bulletin W-318-B4 on Worthington 3-Stage Volute Centrifugal Pumps, Type UC, and 4-page bulletin W-321-B3 on Monobloc Centrifugal Pumps.

Air Nozzles—Lunkenheimer Co., Cincinnati, Ohio. 4-page folder on bronze air nozzles with renewable non-metallic disk, recently described in **Power.**

Speed-Reducing Gear Units — Dominion Engineering Co., Ltd., Montreal, Canada. 24-page Bulletin 127, "Dominion Standard Speed-Reducing Gear Units," gives illustrations, sizes, dimensions, weights and engineering data.

Air Compressors—Sullivan Machinery Co., 400 N. Michigan Ave., Chicago, Ill. 32-page catalog describes Plus Portable 2-Stage Air-Cooled Compressors in four sizes, 105, 106, 210 and 315 cu.ft., available in all desired mountings, describing all accessories and type driven either with gasoline engines or diesels.

Chains and Sprockets — Baldwin-Duckworth Chain Co., Springfield, Mass. Catalog K-1, on Chains and Sprockets for Power Transmission, Conveying and Elevating, contains 54 pages, pocket size. Describes and lists standard roller chains, parts and attachments, multiple roller chains, extended pin chains, and similar equipment, plus a 20-page section of engineering data.

Steel and Products—Lukens Steel Co., Coatesville, Pa. 8-page highly illustrated booklet, "World's Largest Plate Mill and Its Products," summarizes work of Lukens and its divisions, Byproducts Steel Corp. and Lukenweld Inc.

Instruments — Brown Instrument Co., 4490 Wayne Ave., Philadelphia, Pa. 8-page folder "Here is an Operating Cost that is Controllable," describes Brown power-plant instruments.

Rubber Belts—B. F. Goodrich Co., Sales Promotion Dept., Mechanical Div., Akron, Ohio. New folder lists 14 improvements in belt construction during past five years, 6 in manufacturing processes, 4 in fabric, and 4 in rubber compound. 24 photographs from a variety of industries.

Cranes—Whiting Co., Harvey, Ill. 4-page Bulletin 195 on Whiting "LH" and "LHE" traveling cranes, either hand- or electric-powered.

Motorized Speed Reducers — Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill. 20-page illustrated catalog No. 1515 on new line of motorized speed reducers, with motor mounted directly on side of reducer housing; also gives engineering data.

Bucket Elevators—Jeffrey Mfg. Co., Columbus, Ohio. 111-page catalog "Bucket Elevators Standardized Equipment for General Services," illustrates and describes and gives applications of various types of units.

Holyoke—Holyoke Water Power Co., 1 Canal St., Holyoke, Mass. 12-page folder, "Holyoke, A City of Diversified Industries," describes city and power and water and industrial facilities.

Lubrication—Standard Oil Co. (Indiana), 910 S. Michigan Ave., Chicago, Ill. New series of engineering monographs on all phases of industrial lubrication, including such subjects as "The Lubrication Engineer Has Value to You," "The Lubrication of Diesel Air Compressors," "Diesel Engine Bearing Lubrication," "The Lubrication of Meters in Jordan," "The Lubrication of Mine Locomotives." Each is a competent engineering discussion, strikingly illustrated and giving detailed analysis of specific lubrication problems.

NEW PLANT CONSTRUCTION

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Ala., Florence—Municipality bids about June 6, municipal power plant and electric distribution system. P.W.A. project

Calif., Bakersfield — Southern San Joaquin Municipal Utility Dist., proposal to form district carried at special election. The district to distribute irrigation water and power under proposed Central Valley Water Project in the Delano-McFarland area. Directors of the district are E. S. Green, E. L. Borel, E. G. Girard, J. E. Regan, M. R. Marshall, F. E. Smith, Bakersfield, Co. clerk of Kern Co.

Calif., El Centro — Imperial Irrigation Dist., El Centro, authorized M. J. Dowd, engr., c/o Owners, to apply to P.W.A. for $13,500,000 loan to finance construction of hydro-electric power system along the All-American Canal.

Calif., Lodi—City allotted $600,000 loan and grant by P.W.A. to finance construction of Mokelumne River hydro-electric plant, consisting of concrete arch dam 59 ft. high, 27 mi. from Lodi, rein.-con. power house, containing 1,375 kva. generator connected to 4 reaction type water wheels of combined capacity of 1,200 cu.ft. p.s. step-up transformer station at power house, 27 mi. transmission line, step-up transformer station within city limits. F. C. Herman, Merchants Exch. Bldg., W. L. Huber, Crocker, 1st Natl. Bank Bldg., and N. A. Eskart, 425 Mason St., San Francisco, consult. engrs.

Calif., Oceanside — City plans application to P.W.A. for financing construction of municipal light and power plant. $375,000. J. H. Landes, city clk. E. T. Kuehren, supt. P. Wks., Oceanside, engr.

Colo., Ft. Collins—City soon takes bids on 1st section of light plant and distributing system, incl. turbines, boilers, heaters and general equipment. $750,000. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, Mo., engrs.

Fla., Live Oak—City plans electric light and power plant and distribution system. To exceed $40,000. J. F. Ahern, Jacksonville, archt.

Idaho, Twin Falls—Idaho Power Co., Boise, announced power program including 8,400 kva. hydro-electric plant on Snake River, near Twin Falls, incl. dam, tunnel work, road construction. Est. $1,250,000.

Ill., Chicago—Walgreen Co., 744 East Bowen Ave., plans 2 or more small diesel engined electric power units to provide light and power at company's large retail units. If experimental plants are satisfactory units at various other locations in other cities will be constructed.

Ia., Britt—Municipality, M. S. Burgitt, clk., retained A. P. Beyers, engr., Waverly, to make survey of city's electric needs. Report to be made before July 1.

Ia., Iowa City—City plans constructing light plant. $900,000. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, engr.

Kan., Burlington—City plans power plant and distribution system. $145,000. T. Archer & Co., 609 New England Bldg., Kansas City, Mo., engrs. Supreme Court denies privilege of private utility to file injunction.

Mich., Battle Creek — Michigan Carton Co. plans by Shreve, Anderson & Walker, 857 Book Bldg., Detroit, 1 story, basement, brick, steel, rein.-con. power house to house 1,000 hp. boiler, turbine and equipment, incl. 50 ft. steel stack. $100,000.

Minn., Duluth — Diamond Horse Shoe Calk Co., plans by F. C. Perry, Duluth, converting factory into power plant, incl. boilers, generators, etc. To exceed $30,000.

Minn., Glencoe—Bids June 3, by City, F. X. Eickmann, clk., engineering services for making survey of city to determine amount of electricity likely to be consumed in case a municipal electric power and distribution plant is constructed, cost of operating plant, net revenue therefore, etc.; also furnishing plans and specifications for such proposed plant and for superintending plant construction if ordered. $75,000.

Minn., Faribault — State Dpt. Administration & Finance, C. R. Erickson, comr. Purchase, 120 State Capitol, St. Paul, plans hospital for Feeble Minded. $240,000 appropriated; remodeling power house, $30,000 appropriated; and power plant improvements, $45,000 appropriated.

Minn., Mountain Iron — Village, c/o I. A. Blancke, clk., voted $70,000 bonds for power plant enlargement and new equipment.

Minn., Willmar—State Dpt. Administration & Finance, C. R. Erickson, comr. Purchase, State Capitol, St. Paul, plans power plant addition at asylum, here. $45,000 appropriated by state legislature.

Mo., Pattonsburg — City plans constructing light and power plant, equipment, and distribution lines. $67,420. P.W.A. project. E. T. Archer & Co., 609 New England Bldg., Kansas City, engrs., Missouri Power & Light Co., filed petition to prevent city erecting plant.

Mo., St. Louis—City preliminary plans new boilers and power plant equipment, pump discharge line, basin alterations, repairs at Chain of Rocks Pumping Station on Mississippi River, at northern edge of city. Private plans.

N. J., Vineland — Boro Comrs. passed ordinance appropriating $300,000 for improving power house incl. 3,500 kw. steam turbine and generator, stokers and boilers. J. Menzone, city engr.

N. M., Santa Fe — Bureau Indian Affairs, Wash., D. C., plans electric generating plant at Zuni Indian Agency, $30,000 appropriated.

N. Y., Albany—Governor Lehman approved legislative bill providing creation of Albany Light, Heat & Power authority for Albany Co. and extending power to such group for purpose of establishing and operating county owned power and light plant or plants or to acquire facilities of privately owned power company operating in the county or any other county in the state. The 1935 Act limits the financing of proposed county-operated power business to $10,000,000 to be provided by a bond issue.

N. Y., Jamestown — Bd. Pub. Utilities, T. J. McKee, secy., City Hall, bids late in summer installing additional equipment in Steele Street plant of municipal light and power system. P. Loftus, consult. engr., c/o owner, and Pittsburgh, Pa. authorized to prepare plans and specifications. C. O. Johnson, supt.

N. Y., Long Beach — City, C. Gold, mayor, plans municipal light plant. E. R. Sherb, c/o City Hall, consult. engr.

N. Y., Niagara Falls—City bids late in June or early in July constructing heating plant at municipal waterworks. $50,000. P.W.A. project. H. Wesley Clark, city engr.

N. Y., Rome — Dpt. Mental Hygiene, State Office Bldg., Albany, plans by W. E. Haugaard, State Office Bldg., Albany, power house at Rome State School. $250,000. Appropriation granted. **Maturity in 1935.** T. F. Farrell, state engr.

N. Y., Syracuse—New York Central R.R. Co., J. Y. Pfau, ch. engr., 466 Lexington Ave., New York, bids in June constructing power house, mail and express buildings, near proposed passenger station site.

O., Edgerton—Village plans municipal power plant. P.W.A. granted $60,000 loan.

O., Lima—Corporation, c/o F. G. Smith, c/o Lima Ice & Coal Co., plans electric power plant, along Pennsylvania R.R. tracks. $250,000. **Maturity indefinite.**

O., Shaker Heights—Cleveland Railway Co., Midland Bldg., Cleveland, L. B. Bale, engr. in charge, plans booster station, Warrensville Center Rd. $50,000. **Maturity indefinite.** Private plans.

O., Zanesville—Bids June 13, by U. S. Engr., Zanesville, furnishing gasoline-electric stand-by units and accessories for Muskingum Water Shed Conservancy Dist. Dams.

Ore., Portland—June 18, by U. S. Eng., Portland, design, manufacturing and installation one 400 kw. generator and spare parts.

Pa., Bethlehem — City, 53 East Broad St., plans street lighting plant to house generating system, $115,000. P.W.A. loan granted. R. L. Fox, 37 Broad St., engr.

Pa., Titusville — Fisher & Young, W. S. Young, mgr., plans rebuilding saw mill and lumber plant, incl. new boiler house and installation of new equipment and machinery. Enterprise Rd., East Titusville. Architect not appointed. **Maturity at once.**

South Carolina — Lyles-Ford Tri-County Authority, L. G. Young, chn., Union, made application to P.W.A. for loan to finance construction of 3 co-ordinated plants in Fairfield, Union and Newberry Counties on Tiger River, Broad River and Enorel River, $13,214,238. P.W.A. project. D. T. Duncan, Greenwood, engr.

Va., Blackstone — Blackstone Weaving Co., Blackstone, plans power house, machine shop, etc., for textile plant. $60,000. Bryan & Terhune, 2 Rector St., New York, engrs.

Va., McCoy—Bib Vein Coal Co. plans power plant and coal handling building. To exceed $30,000.

Wis., Merillian — Municipality plans hydro-electric power plant. $35,000. W. S. Woods, LaCrosse, engr.

Man., Portage la Prairie — Manitoba Power Comn. plans constructing distribution plant. $50,000.

Ont., Hamilton—Dominion Foundries & Steel Ltd., Depew St. plans construction of additional buildings for tin plate mill to include 50x192 ft. white pickle building, 30x38 ft. boiler house, and 24x175 ft. black pickle building. F. Prack, 1316 Piggott Bldg., archt.

Sask., Prince Albert—Canadian Utilities Ltd. plans purchase of turbo-generator, $90,000.